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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 140.

B. T. GALLOWAY, *Chief of Bureau.*

THE "SPINELESS" PRICKLY PEARS.

BY

DAVID GRIFFITHS,

ASSISTANT AGRICULTURIST, OFFICE OF FARM MANAGEMENT.

ISSUED JANUARY 30, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE,
1909.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., November 4, 1908.

Sir: I have the honor to transmit herewith, and to recommend for publication as Bulletin No. 140 of the series of this Bureau, the accompanying manuscript, entitled "The 'Spineless' Prickly Pears." The paper was submitted by Prof. W. J. Spillman, in charge of the Office of Farm Management, with a view to publication.

This is a preliminary treatment of the subject, which it is desirable to have published at the present time for the information of the many farmers and ranchers in the arid and warmer sections of this country who are vitally interested in forage crops. Some limitations are placed upon the growing of the plants as farm crops which ought to be of service to those who may be misled by ill-advised stories of the phenomenal adaptability of this class of prickly pears in the agriculture of our arid States.

It is not the intention of Doctor Griffiths to discourage activity in the spineless prickly pear industry, for the plants have a use in some sections, and under proper conditions they can be profitably grown as a farm crop. He has simply prescribed some boundaries to their adaptability.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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B. P. I.—428.

THE "SPINELESS" PRICKLY PEARS.

INTRODUCTION.

The nearly thornless forms of certain members of the botanical genus Opuntia are known in various sections of the country under different names. Spineless prickly pear, spineless pear, spineless cactus, nopal, and Indian fig[a] all refer to the same group of plants. This paper deals with those forms of "spineless" prickly pears which are large in stature, comparatively rapid of growth, and of economic importance. They are large, nearly smooth plants which, with no preliminary preparation, cattle can eat without causing them serious inconvenience.

There are many species of prickly pear which are technically spineless, but being either small or having many small spicules they are of practically no economic importance. While these are, strictly speaking, spineless prickly pears, they are excluded from consideration in this paper, for "spineless" is used here in the popular economic sense.

This paper deals with all of the species, varieties, and forms of "spineless" prickly pears from whatever source they may be obtained. The facts laid down here are intended to apply to all of them. No species, varieties, forms, or hybrids of either modern or ancient origin are excepted.

ORIGIN OF "SPINELESS" PRICKLY PEARS.

The origin of "spineless" prickly pears is shrouded in as much obscurity as that of our common cultivated wheat, barley, apples, or any other crop long cultivated by man. It is supposed that there are no prickly pears, either spiny or spineless, which are native to any region of the globe outside of the American continents and their islands. While there are some circumstances which throw doubt upon this opinion, it is quite certain that spineless forms of the plants came originally from America and that they were consequently not known to civilized nations previous to the discovery of the Western Hemisphere. Precisely how they originated nobody can tell with certainty. It is reasonable to suppose and logical to think that they are the result of both conscious and unconscious selection continued through many generations of time, quite likely since long before the voyage of Columbus.

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[a] The name *tuna* is also used, this being the Spanish word for the fruit of these plants.

Mexico must be considered the most important prickly pear country of the world. Its population has obtained a portion of its sustenance from this crop since the earliest tribal times. The prickly pear emblazoned so prominently upon the coat of arms of the modern republic has its origin in legendary history. It is not at all far fetched to suppose that the Mexicans, although then ignorant of the laws of plant breeding, as they are even to-day, made slight improvements in the plants with regard to the spineless characteristics, for although they value some spiny species much more than they do any of the spineless ones they appreciate and take a pride in the spineless forms.

It has been a comparatively simple matter for the Mexicans to hold all the advantage they have gained from time to time by their selections, for the propagation has always been vegetative. Indeed, the plants are never grown from seed in Mexico, and it is commonly supposed among the poorer people, who are the ones that grow them, that they will not reproduce from seed. Many times has the writer been ridiculed for collecting seed of these plants upon the market places, and as many times assured that they would not grow. On one or two occasions cuttings have been brought to him the next day out of sympathy for his ignorance and an earnest desire that his efforts should not prove fruitless.

These circumstances show that vegetative propagation is practiced and that such propagation has a tendency to eliminate spininess where smooth forms are appreciated by even an ignorant peasantry. This, coupled with the fact that all species of the genus are very variable in spine characters and that nearly spineless forms of possibly one-half of the species of the flat-jointed group may be found to-day in nature, would appear to account for the origin of many spineless cultivated varieties. Others are doubtless species which have become nearly or quite extinct except in cultivation.

It has been assumed by some that the improvements of spineless forms were made in the Mediterranean region of Europe. This assumption is possibly based upon the fact that the plants are more numerous there now than elsewhere in the world. It seems rather doubtful to the writer, however, whether this assumption expresses more than a partial truth, for there is an abundance of forms to-day scattered all over Mexico which are just as spineless as any that grow and apparently are identical with the Mediterranean forms. It is quite possible that the spineless forms were taken to Europe from Mexico and South America in much the same condition as they are

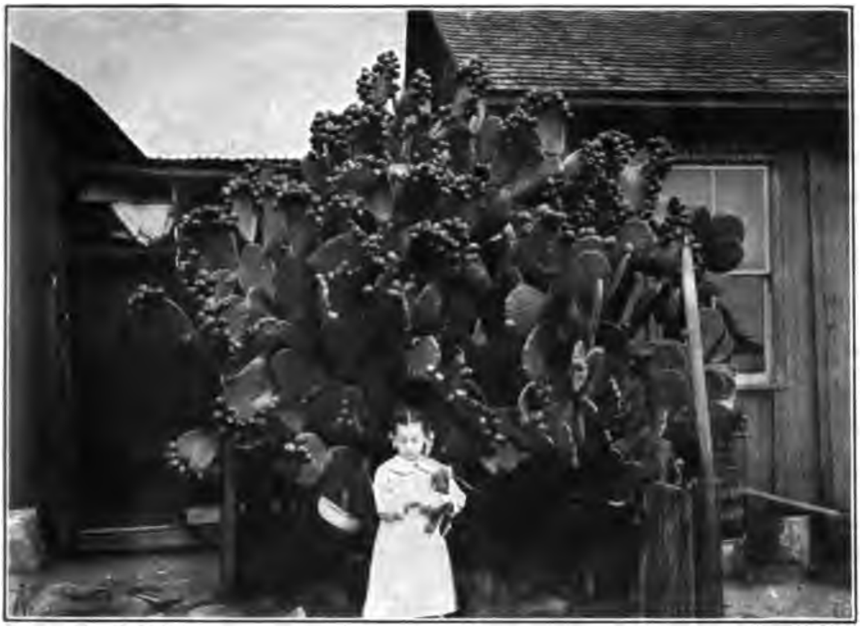

FIG. 1.—A "SPINELESS" PRICKLY PEAR OF A KIND COMMONLY GROWN IN ARIZONA AND CALIFORNIA.

One-third to one-half of the fruits have been picked off.

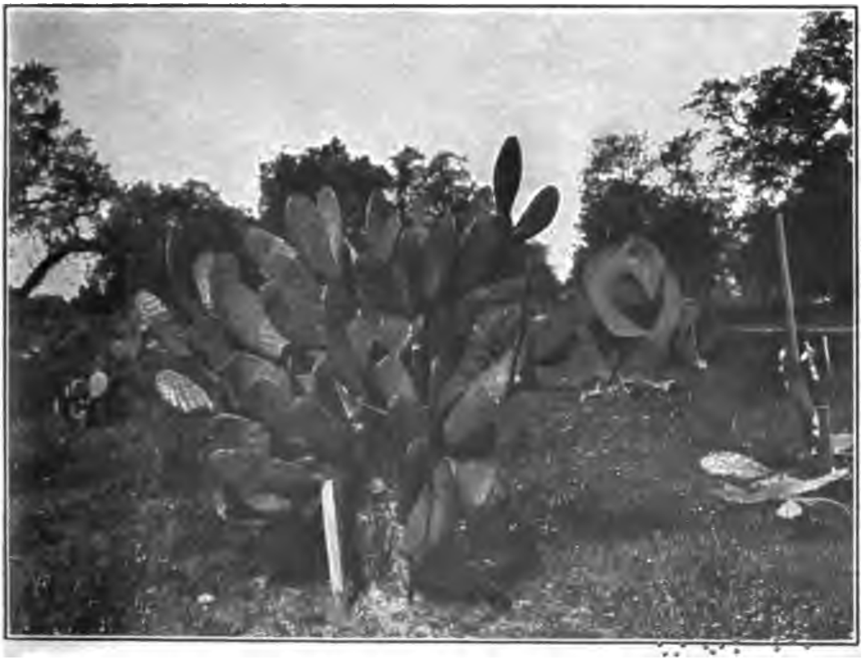

FIG. 2.—A YOUNG PLANT OF A YELLOW-FRUITED "SPINELESS" AND SEEDLESS SPECIES OF PRICKLY PEAR FROM THE ISLAND OF MALTA.

grown there to-day. Our importations of spineless forms from Mexico and southern Europe have as yet not been grown together long enough or studied thoroughly enough, nor have our investigations in Mexico been sufficient to warrant an opinion as to the identity of the forms. Certain it is that there are some Mexican varieties which seem thus far to be identical with those of southern Europe. Others appear different.

Four spineless varieties are common in this country and have been cultivated for so long a time that their origin is not known. Some of these are as spineless as any known to science to-day.

AREAS WHERE "SPINELESS" PRICKLY PEARS ARE FOUND.

In the United States there exists to-day a considerable stock of spineless forms of prickly pears. Possibly not less than a half dozen species and varieties are more or less common in gardens and private collections of the warmer sections, notably in California, in extreme southern Arizona (see Pl. I, fig. 1), on the coast of Texas, and in Florida. There is nowhere any large number of specimens, only a few plants usually being cared for.

The varieties commonly found in this country are few in number compared with those of other warm regions. During the past five years not less than twenty-five varieties have been imported by the Bureau of Plant Industry. They have come from Mexico; the Mediterranean region of Europe, Asia, and Africa; the Hawaiian Islands; and from some South American countries. There are forms grown commonly in South Africa and in Australia and some of the other Pacific islands. It is believed that there are not less than thirty species and varieties belonging to the two genera Opuntia and Nopalea which have an agricultural value. The small, technically spineless but spiculed forms of no economic value are not considered in this list. Only those which are rapid in growth and become large plants are considered here.

CHARACTERISTICS OF A GOOD "SPINELESS" PRICKLY PEAR.

A good prickly pear of any kind must be first of all a rapid grower. This is the all-important consideration within the zone in which the plant is hardy. The chemical composition of the plant may be left entirely out of consideration, for the rapid-growing spineless forms do not differ enough in composition to make it worth while to consider that feature.

The feature next in importance to rapidity of growth is good habit of growth. There is much more in this subject than one would be inclined to believe at first, and the writer's limited experience does not warrant a full discussion at this time. It must be remembered that the raising of spineless prickly pears is in no sense a range proposition. The plants can not be put out to shift for themselves; they must be farmed like any other crop. Above all, in order to produce they must be cultivated, and to be cultivated they must have a habit of growth that will permit it. There are some varieties of quite rapid growth which have a reclining habit. This would make it very difficult to get around them without having the tools break them down badly, necessitating a great deal of hand work in keeping down weeds. The writer is not ready at present to discuss the different varieties in respect to habit, for no one in this country has yet grown any of the forms under field conditions. While the plants need to be erect to facilitate cultivation, it must be remembered that they are very brittle and consequently must not be of the spindling kind not strong enough to support themselves or withstand the force of winds of the region in which they are grown. In short, the variety best suited to cultivation is rapid in growth and erect and stocky in habit.

PERMANENCY OF THE SPINELESS CHARACTER.

Since all spineless prickly pears are more or less spiny it is naturally to be expected that under certain conditions they will become more so. What all the conditions which affect the development of spines may be the writer is not now prepared to discuss in detail, and the suggestions given here are only tentative and reservedly stated.

It has been shown in another publication[a] that the spiny prickly pears which are natives of Texas become even more spiny under cultivation in the same locality. So far as investigations thus far conducted are concerned, good conditions do not increase the numbers or size of the spines of the spineless species. Upon the immediate coast of California, under the influence of sea breezes, the forms of *Opuntia ficus-indica* do not develop into such smooth plants as they do farther inland, where the temperatures are higher, the winds less severe, the sea breezes cut off, and the plants less dwarfed. The spines do not appear to increase so much as the spicules.

The conditions to the northwest of the Salton Sea are also favorable to the development of spicules upon this species. The forms become considerably more difficult to handle when grown there. The same appears to be true in the Salt River Valley. *Opuntia monacantha*, another introduced species, while much dwarfed wherever grown in this country, does not seem to increase its spines or spicules under the above conditions. It is, however, a spiny species.

In short, it seems from investigations thus far conducted that hard, unfavorable conditions, such as proximity to the sea, alkalinity, extreme heat, extreme drought, and possibly low temperatures, contribute to increase the spines of these nearly smooth opuntias. But while this is true, observations thus far made do not indicate that there is any probability that the spines or spicules will increase until these prickly pears will require singeing before cattle can eat them. The increase is not at all alarming, even after four or five years' growth in unfavorable situations. While there appears to be an increase, it is believed that this feature can be left out of consideration from an economic point of view. While there may be a slight increase of spicules, especially under unfavorable circumstances, it will not be enough to make any practical difference, although of a great deal of scientific interest.

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[a] Bulletin No. 124, of the Bureau of Plant Industry, entitled "The Prickly Pear as a Farm Crop."

TREATMENT OF CUTTINGS.

There appears to be among certain horticulturists and others an opinion that prickly pears must be abused in order that their growth may be insured. Nothing can be farther from the truth. These plants thrive best when most carefully managed. The practice of wilting the joints in greenhouse culture has arisen from the fact that the average greenhouse is a very artificial and inappropriate place to grow cacti of any description. The ground is commonly more wet than that to which the plants are accustomed and the atmosphere contains altogether more moisture than most situations where plants of this class grow. Even here no wilting of the cuttings is necessary. It is essential, however, under moist conditions to have the cut surface well dried before placing it in moist earth; otherwise it will start to decay and communicate decay to adjacent healthy tissue instead of healing over and callousing, as in other woody plants. The prickly pear cutting does not form a callus upon the cut surface and root from the callus like the common fruits; it simply heals over. Roots grow from areoles, or cushions, from which the spines and spicules develop.

It is no more necessary to wilt cuttings of prickly pears than it is to wilt cuttings of the grape, or willow, or privet before planting them. The only difference is that the prickly pear, on account of the large amount of moisture in its tissues, can withstand such treatment, while the other plants can not. Being able to endure it the treatment insures the drying of the cut surface, which is imperative under moist or wet conditions.

The fact that cacti are able to withstand certain abuses is no proof that such conditions are best suited to their growth. That the plants are sometimes able to exist on the top of adobe buildings or even on a board roof is not proof of their adaptability for growth as forage upon deserts, nor is it evidence that they should receive abusive treatment in order to develop properly. Plants in our possession have lived for two years while hanging upon a barbed-wire fence, and they made some new growth, too, but it was at the expense of the old. These instances are simply interesting and should not be accepted as proof that hard treatment is necessary in order to have the plants make their best development.

The writer's experience is sufficient proof that under open-air conditions in our arid and semiarid States no wilting of the joints is necessary. In the spring of 1908 about 3,000 cuttings were planted upon the propagating grounds at Chico, Cal. In no case did more than an hour elapse between the removal of the stock from the parent plant and its insertion into the ground in permanent position. It is quite probable that at least half of the cuttings were actually planted in less than twenty minutes after they were cut. The writer prepared the cuttings with a spade. Two or three men were employed to distribute them, and another man followed with a team and plow and covered them. Less than 1 per cent of the cuttings died from all causes. There is no evidence that any were lost from rot due to the failure to wilt them. The ground was rather dry, however, but not so dry but that the cuttings made a good growth and were in a thriving, healthy condition when the writer saw them the following August. There were, in all, about 30 varieties, both spineless and spiny, the former predominating.

The same spring a large planting was made at San Antonio, Tex., also. In this case about 600 cuttings, representing one-half as many varieties, were planted in very wet soil. Indeed, planting was delayed several days in order that the ground could be worked. A rain followed close upon the planting, and rains occurred at frequent intervals during the entire summer. It was really the wettest season in many years, the ground being in such condition during the early part of the summer that proper cultivation could not be practiced. Still, less than 2 per cent of the cuttings died from all causes. A few rotted at the surface of the ground and the plants fell over in midsummer, but this was due in every case, as investigation subsequently proved, to the ravages of white grubs.

In the spring of 1906, which was a normal season, 6 acres of spiny natives were planted at San Antonio, Tex. The cuttings were set 2 feet apart in 6-foot rows. This gave, in round numbers, 4,500 cuttings to the acre. One half of the cuttings was planted by being plowed in; the other half was simply placed in position on the surface of the ground in firm contact with the soil. In this case stock was secured from a neighboring field, large plants being cut down, loaded into wagons, and distributed upon the field. These were subsequently chopped up into single joints with a spade, distributed in a furrow, and then covered with a plow following close behind. In some cases twenty-four hours elapsed between the preparation of the cuttings and their setting in the ground; in other cases only a few minutes. A practically perfect stand was secured over the entire field.

Certainly no further evidence is necessary to convince anyone that the wilting of the cuttings is, at least, superfluous.

If the cuttings are allowed to lie on a surface of damp ground for a week or ten days, they will start a root system in the spots (areoles) in contact with the earth and absorb water to make up for that lost by evaporation. If the ground be dry they will suffer, and in very hot regions they will often be killed in a short while when they have no chance to make up for the loss of evaporation from such severe exposure.

In short, cuttings of prickly pears do not need wilting before being planted. They will wilt enough in the ground under ordinary conditions before they can strike root. Whatever water is lost by evaporation must be made up again by absorption before the plant will make its best growth. The wilting simply weakens the plant.

PLANTING.

The planting of prickly pears does not differ materially from that of any other crop except that one has, owing to their resistance, more latitude with these cuttings than with those of almost any other crop. However, it must be remembered that the grower will be charged up with any abuse which the plants receive.

Under any ordinary conditions the cuttings should be planted as soon as prepared. When they have been shipped from a distance no time should be lost in getting them into the ground. If they have been bruised in handling and show blackened decayed spots, these should be cut out with a sharp knife and the cut surface, if it is to go into the ground, allowed to dry thoroughly—in the shade if the sun is very hot. If the cut surface will be above ground when the cutting is planted or if the ground is dry, obviously no drying is necessary and the cutting should be set immediately.

The cuttings will ordinarily consist of single joints of stem cut close to the articulation or constriction between them. These should be buried in the ground to one-half their length unless the cutting be very small, when more than this proportion should be buried. When few cuttings are to be planted they can be set upright by hand, but much labor can be saved in large plantings by opening up a furrow with a plow. The cuttings are then distributed at proper distances and leaned against one side of this shallow ditch. Another furrow is then turned over on the cuttings in position. Care should be exercised not to completely cover any of them, for they do not appear to have any power of pushing up new growth through the soil. Subsequent cultivation will level off the ground.

Lack of experience in growing the spineless prickly pears in this country renders it difficult to say at exactly what distances they should be planted. Judging from our experiences with spiny forms it is thought that 3 feet apart in 6-foot rows is the most advantageous distance when the plants are to be grown for forage and harvested every two or three years. If it is intended to grow the plants to maturity, 8 by 8 feet is none too much room; it is possible that 10 by 10 feet would be better.

CULTIVATION.

The ground should be deeply and thoroughly prepared. Subsequent cultivation should be frequent enough to prevent the soil from baking, to preserve the moisture, and to keep down weeds.

So far as known, no one in this country has had experience in the use of fertilizer on these plants.

HARVESTING.

It is quite probable that it will prove to be best to harvest spineless as well as spiny prickly pears biennially. It may be that in certain favored localities enough growth will occur for harvesting each year, but the feed will be a little better if allowed to stand upon the plants the second year, as it will then contain more substance and be less watery. It has been our experience that a growth of the spiny Texas pear of even 23 tons to the acre is not enough to be harvested advantageously. There are few sections where it is thought the growth of any of the spineless species without irrigation will be in excess of this.

When harvesting is done the plants are cut down, preferably with an instrument resembling a spade. A hoe straightened out so that the blade is in line with the handle is very suitable. A quick chop with such an instrument will sever most stems.

The harvesting should not be too close. Enough of the old stump should be left to preserve a good surface for the production of new growth. The cut surface should be left as clean-cut as possible. Quick, vigorous action with the instrument, insuring the felling of the plant or branch at one stroke, will produce the best results. In no case should a ragged surface be left upon the stump; it will usually be better to make a new cut lower down, trimming off the ragged edges. Where possible, the cut should be made just above rather than just below the articulation between the joints.

The crop will always be harvested as needed. It is not adapted to being stored, cured, or housed, but may be harvested at any season of the year. Experience with spiny forms indicates that the stump is more likely to decay when harvesting is done in cold, moist weather. However, this is a point to be worked out. More data are needed upon it.

When cut down the plants can be loaded on wagons with forks and hauled to the feed lot. Too much waste will attend the turning of cattle into the field.

RESISTANCE TO COLD.

The accompanying map (fig. 1) shows in a graphic way where spineless cacti, according to our best judgment, are adapted to grow. The Bureau of Plant Industry has as yet grown plants in but little of the territory thus outlined, but the writer has had a large experience through the entire region and believes that he has been liberal in allotting territory to this crop.

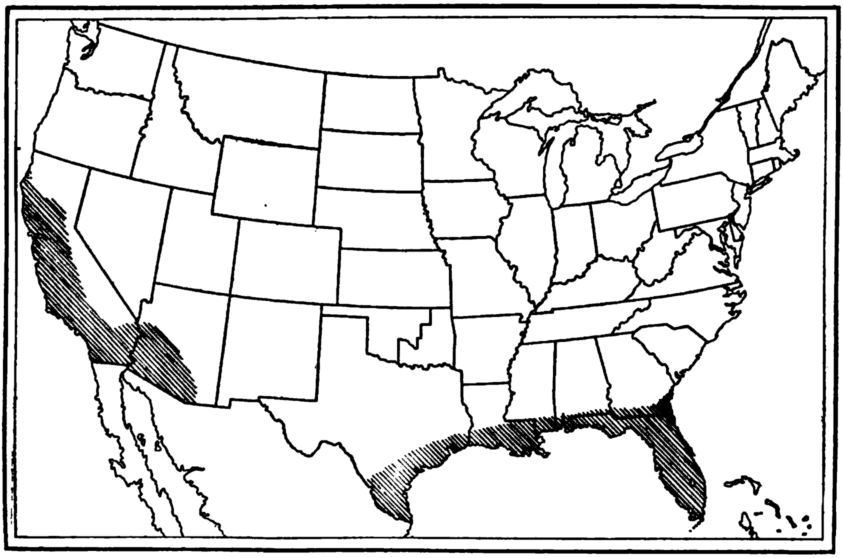

FIG. 1.—Map of the United States, showing the areas (shaded) where "spineless" prickly pears may be grown. The minimum winter temperatures will prevent their growth outside of the shaded areas.

It must be remembered that throughout this region live many Mexican families. They take with them the prized nopal, both spineless and spiny, wherever they go. They may not cultivate it, for they have not been used to doing that, but they will put cuttings in the ground and throw a little water on them occasionally. Were it possible to secure records of all the work which these poor people have done in this line it would be feasible to-day to mark absolutely the limit of possible spineless pear culture in the United States, west of Louisiana at least. But such records are impossible to secure satisfactorily, although the writer has been greatly aided by the suggestions and information furnished by these people. It will be necessary to try to perform in many places what they have already tried to do in a small way and failed. However, their work is in evidence in many places and affords a good basis for information.

A single illustration of the value of these Mexican importations will suffice. At Phoenix, Ariz., there are commonly grown in dooryards plants of *Opuntia ficus-indica*, probably introduced by Mexicans, but this is not material. They are there and their habits are known to observant people. Dr. R. E. Kunze finds that his plants freeze and drop off every winter after they get more than about 9 feet high, when they lose the protection of surrounding shrubbery. All horizontal branches which are therefore poorly supported are almost sure to break off during the winter on account of the cold. It is certain that the injury under field conditions would be greater than this. This is proof conclusive that the conditions at Phoenix are about the limit of the endurance of the plants.

The spiny mission pear is also found at Phoenix, Ariz., and it behaves like the spineless *Opuntia ficus-indica*. It is as hardy as any of the spineless forms, and more hardy than most of them. The probability is that the spineless form now growing there is only one of many that have been planted and that it survives simply because it is more hardy than the others; but even this form is not perfectly adapted to this locality.

The experience of the Bureau of Plant Industry at San Antonio, Tex., has been stated in other publications. Out of about twenty-five species and varieties of "spineless" prickly pears planted there, none will thrive without winter protection.

PRICKLY PEARS IN A COLD REGION.

Under the previous heading is discussed the area adapted to the culture of the crop. There is no doubt that spineless plants may be bred to withstand a greater degree of cold than any that now exist, but there is a limit to profitable efforts in this direction.

Suppose, for instance, that it were possible to produce twenty tons of spineless cactus to the acre in western South Dakota. It could be fed to stock only during the warm portion of the year. It would be of practically no value during the long cold winters when most needed. It would be frozen like an icicle at any temperature below 18° F. Cattle, according to our experience, will eat frozen pear, but they do not thrive on it.

MOISTURE REQUIREMENTS OF PRICKLY PEARS.

The growing of "spineless" prickly pears in this country as a field crop is as yet only an experiment. There is no instance where any of the varieties have been grown even to the extent of an acre, except possibly in the case of the vague and imperfectly recorded operations of Turnbull in Florida. It is not surprising, therefore, that it is impossible at the present time to say just what are the moisture requirements of "spineless" prickly pears. We know, however, certain limits and are able to map out certain crude boundaries.

The writer believes that the plants will grow under cultivation without irrigation on the Gulf coast of Texas and in California from the Sacramento Valley south. Under the influence of the ocean they may get along with neither cultivation nor irrigation, but in the interior valleys they will have to be carefully cultivated in order to conserve the moisture after the rains cease in the spring. Experience has proved this at Chico, Cal.

In the great arid interior region extending eastward from the southern Sierras, the prickly pears will have to be irrigated before they will make any growth worth while.

The statement which the writer made in a previous publication applies with equal force here and will bear repetition. The prickly-pear plants are adapted to a region having a considerable rainfall too irregularly distributed for ordinary crops. They must have water to grow and considerable of it. They are the camels of the vegetable world. They must have water, but they can get along for long periods without it.

INVESTIGATIONS NECESSARY.

The reader who has followed these pages thus far will readily recognize that what is needed in the "spineless" prickly pears to-day is greater hardiness. This quality can not be bred into them in two or three years. There are spiny species which will live under temperatures of 40° F. below zero, but these are of no value as forage. It will be necessary to combine the characteristics of the spineless varities of to-day with the hardy characters of some of those very spiny hardier forms in order to make them of value in the colder arid regions.

It might be possible by careful breeding and selection in a decade or more to increase the hardiness of the rapid-growing prickly pears so as to withstand a temperature of somewhere about zero instead of 20° or 25° F., which are the limiting temperatures now. There are large spiny species which are hardy at this temperature and will form a much better basis for improvement than the small runty forms of the North. This will push the limit of their cultivation to the northward very materially. Even this will take much patient toil and labor and many years of experimentation.

There are two ways of attacking the problem. One may depend upon selection alone. To gain hardiness by this method one would be obliged to discard the present spineless species entirely and work with the hardy spiny natives, for it can not be expected that the spineless forms can be so improved within themselves as to withstand 25 degrees more of cold than they do now. It would be a problem, indeed, to eliminate spines and spicules and at the same time bring the stature and rapidity of growth of even such a plant as *Opuntia lindheimeri* up to that of the present spineless forms.

The other way is to hybridize the present spineless forms with some hardy plant possessing as many desirable characters as possible. It will usually be necessary to grow this hybrid to maturity, plant its seeds, and then begin a long series of selections from these so-called second generation hybrids. But it will take a season to produce the hybrid, five years more to bring this hybrid to maturity, and two or three years more to bring the seedlings of the second generation to a stage sufficiently advanced to justify selection. One is then ready, provided no accidents have happened and the species which he has selected will hybridize, to begin selection. It will be necessary to decide whether selections can be made most advantageously from vegetable (cuttings) or sexual (seed) propagation. The slight variation that occurs in vegetative propagation renders this method of improvement practically useless. The method of improvement by seed selection requires several generations of plants.

When it is remembered that cacti can be grown from seed only with difficulty and that several years are required to grow a generation to the stage of seed production, the magnitude of the task of improving cacti is easily seen. Of course one can only guess at the number of generations necessary to select from in order to produce a spineless, rapid-growing, hardy progeny from two such parents as we have assumed. We are safe in presuming that it would take several. It must be remembered that neither of the parents is really spineless, even the so-called "spineless" one having some spines and a strong tendency to revert to a more spiny condition. If we could be satisfied with a spiny plant, the problem would be very much simplified. It takes a long time to breed the spines off entirely, or even practically, but to produce a hardy rapid-growing plant should not be so difficult provided one's conception of hardiness is not too exacting. The prediction is ventured that if any improvement is made in the hardiness of rapid-growing varieties it will be through the spiny plants and not the spineless ones.

The main work which the Bureau of Plant Industry will undertake with spineless species during the next two or three years is to test varieties which are now being propagated. Vastly more knowledge is necessary regarding these before anyone will be in a position to inaugurate breeding operations.

THE PRICKLY PEAR A FARM, NOT A RANGE, CROP.

In no sense is the growing of "spineless" prickly pears a range proposition. The plants will no more thrive upon the open range when planted and allowed to shift for themselves than sorghum, sugar cane, or corn in any portion of the United States of America. They will have to be carefully husbanded like any other crop. All rodents are fond of them, and where abundant enough, as they are in the majority of range sections, these alone would exterminate the plants. Even in fenced pastures, where practically no rodents might occur, the live stock would exterminate the plants, as the writer has shown in previous publications.

There is no use whatever in considering the growing of this crop from any other standpoint than in a fenced and cultivated field from which all animals are excluded, unless the area be large enough to supply more feed than the rabbits, mice, rats, and gophers can eat up. The prickly pear is purely a crop to be farmed. It is a mistake to expect the crop to take care of itself when once planted.

"SPINELESS" PRICKLY PEARS COMPARED WITH OTHER FEEDS.

No direct tests have been made to show the relative value of "spineless" prickly pears and other kinds of roughage. In another publication[a] the writer showed that 6 tons of green, succulent, spiny prickly pears when singed were equal as a roughage to 1 ton of sorghum hay. The chemical composition of the spiny prickly pears (*Opuntia lindheimeri*) used in the experiments from which this comparison was drawn is not sufficiently different from that of the spineless forms to warrant a change in the above ratio when an estimate is made of the value of the spineless forms.

It should be understood that prickly pear is only a roughage at best and should never be considered as anything else. Quite a number of chemical analyses of spineless forms have been published, but the data are always incomplete. In only one or two cases are we told what portion of the plant was analyzed. There is often more difference in composition between portions of the same plant varying two or three years in age than there is between different species. The fact that some of these analyses show up extraordinarily large in water is therefore misleading. It is the judgment of the writer that the difference between the actual results obtained in feeding the spiny and the spineless forms of prickly pears will be very slight indeed. It should be remembered that prickly pear is a roughage; it is high in water content, low in nutritive value, very palatable to stock, and must be fed in large quantities, 90 to 150 pounds a day, to produce good results.

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[a] Bul. 91, Bureau of Animal Industry, U. S. Dept. Agriculture.

HOW FARMERS CAN SECURE PRICKLY PEARS FROM THE DEPARTMENT OF AGRICULTURE.

There are a number of nurserymen who have now on hand stock of some varieties of prickly pears and are offering the plants for sale, usually under the name of "spineless cactus." Farmers who desire to grow this crop should consult the map on page 15. If located outside of the area shown, no one will be justified in spending either time or money in the expectation of making an economic crop out of "spineless" prickly pears. Outside the shaded area on the map, attention should be given to spiny, hardy varieties.

The Department of Agriculture will have for distribution in the spring of 1909 about 7,000 to 9,000 cuttings of "spineless" prickly pears. Some of these will be used in special experimental work by the Department, and the remainder will be furnished to those who apply for the cuttings previous to the middle of February, 1909.

Applications will be filed in the order of their receipt. Should there not be enough stock to fill all demands at that time, cuttings will be sent either the following August or February, depending upon the number of applications received and the amount of stock on hand.

No stock will be distributed outside of the territory marked as adapted to growing these plants on page 15, except it be a cutting or two which may be desired for a special purpose and which will receive winter protection.

Applications for cuttings should be made to the Office of Farm Management, Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C.

NATURE AND ORIGIN OF THE PRICKLY PEARS TO BE DISTRIBUTED.

At various times during the past ten or fifteen years the Office of Foreign Seed and Plant Introduction of this Department has imported small quantities of stock of "spineless" prickly pears from the Mediterranean region. This material has either been kept in a greenhouse in Washington or distributed gratis to various individuals throughout the country, with little if any attention being paid to it afterwards until the past few years. This promiscuous distribution forms the basis of the greater part of the spineless stock in this country now.

Since 1904 a systematic effort has been made to secure all the information available about the plants. Personal explorations have been made, mainly in Mexico and the United States. In other regions dependence has necessarily been placed on correspondents. From all sources, however, approximately 500 species and varieties of prickly pears have been introduced. About 25 of these are spineless, and 10 or 12 of them are sufficiently promising to warrant their being sent out to growers interested in them. Some are of Mediterranean origin (see Pl. I, fig. 2) and some of Mexican origin.

In no case was there any large amount of stock of any variety imported, usually only 3 to 6 cuttings. Having but meager information about the different varieties, it was thought better in many cases to divide even this small amount of material between two or more localities in order to insure having it preserved in one situation should it not succeed in another, and this precaution has proved to be a wise one. On this account it has taken four years to bring together sufficient stock to warrant distribution on any extended scale.

With such a large importation of material there is a great range of varieties to select from, from the spiniest to the least spiny of any that are known. The so-called "spineless" ones which will be distributed vary in the number of spines. Like all material known to science to-day none of them is entirely spineless, and there is none perfectly spineless anywhere. But in all of these the spines are so unimportant that they can be easily handled and stock can eat them without singeing. They have been neither bred nor selected. They have been subjected to no horticultural manipulations whatever in our hands. They are exactly as we found them, and similar plants may be secured by anyone in the same localities where these were obtained. All that the Department of Agriculture has done is to import the stock and propagate it.

Distributions will not be confined to the spineless species. So far as stock is available, others will also be sent out if there is call for them. There are many very spiny species which bear fruit as good or even better than the spineless ones. However, nearly all of the spineless varieties produce edible fruits.

It should be remembered in this connection that although the plant body of this group of prickly pears is spineless, the fruits of all of them have many of the small spicules, rendering them somewhat disagreeable to handle.[a] There are no prickly pears anywhere with smooth fruits. The nearest approach to this condition is in the genus Nopalea (the vast majority of the prickly pears belonging to the genus Opuntia), in which one species is found which is not only smooth in plant body, but has fruits which are also nearly smooth; but even here there are a few of the small spicules, and the fruit is of no value.

The following table contains a partial list of the species of prickly pears which will be ready for distribution in February. They will be distributed under the numbers in the first column. The names are almost invariably those under which the importations were received and consequently can not be vouched for in all cases. There are many others which may be distributed sparingly, but the stock of them is at present very limited.

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[a] For directions regarding the handling of these fruits by the Mexicans, see Bulletin 116, Bureau of Plant Industry, entitled "The Tuna as Food for Man."

Table I.—*Species and descriptions of prickly pears of which the Department of Agriculture will distribute cuttings in territory of the United States adapted to their growth.*

Number assigned to species.	Name of prickly pear.	Origin of plant.	Kind of fruit.	Condition as to spines.
14807 S. P. I.	Opuntia ficus-indica	Malta	White, large	Spineless.
8032 D. G	Nopal amarillo	Mexico	Yellow, large	Spiny.
8094 D. G	Opuntia fusicaulis	do	(?)	Spineless.
14819 S. P. I.	Opuntia ficus-indica	Sicily	(?)	Do.
14809 S. P. I.	do	Malta	Reddish yellow, seedless.	Do.
15839 S. P. I.	Españoles	Spain	Good	Do.
14820 S. P. I.	Bianchi Opuntia ficus-indica	Sicily	(?)	Do.
14818 S. P. I.	do Senza chiupi	do	(?)	Some spiny; others spineless.
15841 S. P. I.	Moscatel	Spain	(?)	(?)
1258 P. I. G	(?)	California	(?)	Partially spiny.
1257 P. I. G	(?)	do	(?)	Do.
1256 P. I. G	(?)	do	(?)	Do.
8074 D. G	Incarnadillo	Mexico	Large	Spiny.
14983 S. P. I.	Opuntia robusta	Tunis	Large, purplish red	Spineless.
14982 S. P. I.	Opuntia ficus-indica	do	(?)	Do.
15943 S. P. I.[a]	do	(?)	(?)	Do.
15842 S. P. I.	Tintillas	Spain	(?)	Spiny.
8043 D. G	Nopal tapon liso	Mexico	Large, purple	Spineless.
8105 D. G	Nopal colorado	do	Large, red, mottled.	Spiny.
8121 D. G	Nopal arton	do	Medium in size, deep red.	Do.
14808 S. P. I.	Opuntia ficus-indica	Malta	Red	Spineless.
8126 D. G	(?)	Mexico	Red, small	Spiny.
8140 D. G	Nopal camueso	do	Red, large	Partially spiny.
8146 D. G	Nopal blanco	do	White, large	Spiny.
15777 S. P. I.	Opuntia gymnocarpa	France	(?)	Do.
15843 S. P. I.	Franceses	Spain	(?)	Do.
8092 D. G	Nopal tapon	Mexico	Red, large	Do.

[a] This number is probably wrong.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 141, PART I.

B. T. GALLOWAY, *Chief of Bureau*

UNIV. OF MICH.
NOV 16 190

THE RELATION OF NICOTINE TO THE QUALITY OF TOBACCO.

BY

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ISSUED SEPTEMBER 18, 1908.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1908.

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THE RELATION OF NICOTINE TO THE QUALITY OF TOBACCO.

VARIATION IN THE NICOTINE CONTENT OF TOBACCO.

Nicotine has long been recognized as the characteristic alkaloid of tobacco, but its function in the economy of the plant is not understood. It is present in the plant in the earliest stages of growth and is found alike in the roots, stalks, stems, and leaves. As the development and growth of the plant proceed the percentage of nicotine contained in the leaf constantly increases, reaching its maximum at maturity. On the other hand, as is well known, the maximum content of protein nitrogen is found in the young green leaves which are growing rapidly. These facts seem to indicate that nicotine does not enter into the synthesis of the albuminoids from simpler forms of nitrogen, but rather that it is derived from katabolic changes in the albuminoid constituents, and thus continues to accumulate in the tissues so long as these are vitally active.

The amount of nicotine contained in tobacco from different sources is subject to very wide variations, some samples containing less than 1 per cent, while others contain more than 5 per cent. The production of this alkaloid in the plant is influenced by a large number of factors, the relative importance of which has not been determined. No reliable conclusions can be drawn from a study of the nicotine content of tobaccos grown in different parts of the world for the reason that we are always dealing with a complex group of factors and the effect of any single factor can be determined only by experiments so planned and conducted as to exclude, or at least to control, the effects of all others. In a very general way, however, it can be said that very rich heavy soils and excessive quantities of nitrogenous fertilizers, which tend to produce a coarse, rank growth, produce a high percentage of nicotine. This relation is but a rough one and applicable only to sharply contrasted differences in soils and fertilizers. The investigation of this subject carried on by the writer, though as yet incomplete, points unmistakably to the fact that in the case of any given variety of tobacco grown in a particular locality—that is, under approximately the same environment—the percentage of nicotine in different strains is roughly proportional to the albuminoid nitrogen; but when markedly different varieties grown in different localities are compared, this relation does not hold.

From what has been said concerning the production of nicotine and its functions in the economy of the plant it might be inferred that the amount formed is controlled by external conditions of environment and not by heredity, but our experiments along this line with several varieties and strains, as well as with hybrids, have shown conclusively that there is a well-defined varietal influence distinct from external conditions, such as soil, fertilizers, temperature, moisture, and sunlight. As has been stated in a previous publication of this Department,[a] there is every reason to believe that by systematic breeding it is practicable to procure strains of the important types of tobacco characterized by a high or a low nicotine content, provided the external conditions with reference to soils, fertilizers, and cultural methods are properly controlled. Extensive experiments with this object in view are now well under way. This work includes not only a systematic study as regards their nicotine content of large numbers of selections from different types, but also experiments intended to determine the relative influence on the production of nicotine of the various factors which go to make up the environment in which the plant grows. To these should be added the effects of topping and suckering, practices which are now almost universal.

It has already been stated that the maximum content of nicotine in the case of the leaf of the tobacco plant is attained just as the leaf reaches maturity. After this period the leaf begins to lose a part of its nicotine whether the plant is allowed to remain in the field or is harvested. Every tobacco grower is familiar with the sharp, pungent odor so noticeable in the curing shed and in the fermentation room, and this odor is due primarily to the nicotine which is escaping from the tobacco. From the time the tobacco is hung in the curing shed it continues to lose nicotine throughout the curing, fermentation, and aging processes. The writer has found that well fermented samples of cigar tobacco are still slowly losing their nicotine after being kept in tightly stoppered bottles for more than two years. The cause of this continued loss of nicotine will be discussed later.

RELATION OF TOTAL NICOTINE CONTENT TO THE QUALITY OF TOBACCO.

Although nicotine is the active principle of tobacco its production in large quantities is not desirable. On the contrary, the finest grades of tobacco contain only moderate (and even relatively small) amounts of this principle. It has long been recognized that the aroma is not governed by the amount of nicotine in the leaf, but some investigators have suggested that this important quality is due to its decomposition products formed during the fermentation process. No direct evidence has been furnished in support of this view, and several facts point to the contrary. But even if this view be correct it does not follow that a high nicotine content is desirable, for in the matter of aroma we have to do with quality rather than with quantity.

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[a] Bureau of Plant Industry Bulletin No. 102, Part VII. "A New Method for the Determination of Nicotine in Tobacco." 1907.

As regards the so-called "strength" of tobacco, the case is somewhat different. This term is frequently used to designate the degree of physiological reaction of the system to the use of the tobacco in question, and when thus restricted the "strength" of a sample of tobacco depends on the amount of nicotine present. But this term is also frequently applied to the more direct effect of the tobacco or its smoke on the mucous membrane of the throat and nose. For example, when a high-grade Havana cigar is smoked it proves extremely satisfying to the smoker and produces a marked physiological reaction, while the smoke exerts only a remarkably bland effect on the mucous membrane. On the other hand, some of our domestic cigar-filler tobaccos when smoked are not only less satisfying in their narcotic effects, but the smoke has a marked pungency and is irritating and biting to the nose and throat. These tobaccos are almost invariably classed as strong as compared with the Havana, whereas they actually contain less nicotine than the latter. Of course, these same differences may also be noted in different samples of the various domestic types. A long series of comparative tests conducted by the Bureau of Plant Industry has failed to establish any direct relation between the nicotine content and the strength of the various samples of domestic filler tobaccos as judged and classified by a number of habitual smokers.

In any event it seems best to consider the term "strength" as a composite one, made up essentially of two factors. The true physiological action which constitutes the satisfying effects to the consumer so strikingly exemplified in the Havana tobacco is commonly spoken of as "fullness" of the smoke, while the relative freedom from the pungent, biting quality is designated by the term "smoothness." Thus, the Havana cigar tobaccos owe their great popularity among discriminating smokers largely to the marked fullness and smoothness of the smoke, while nearly all of our domestic filler tobaccos possessing sufficient fullness are characterized by a more or less well-defined roughness or harshness. Fullness and smoothness are generally, but not necessarily, opposed qualities of tobacco smoke.

DIFFERENT FORMS OF NICOTINE IN TOBACCO.

It has often been found in attempts to grow cigar-filler tobaccos in this country from Cuban seed and under conditions of soil and climate resembling those of Cuba that although of excellent quality in other respects the smoke possesses the peculiar pungency or harshness just mentioned. This defect is partially and sometimes efficiently remedied by resweating, followed by a long aging process. In some cases this resort fails and it is necessary to blend the tobacco with some very mild type before it can be used to advantage in the manufacture of cigars. This sharp, biting quality has often been attributed to the presence of an ethereal oil, but such a substance has never been isolated from cured tobacco.

In the course of our experiments with a sample of domestic filler tobacco possessing the above-mentioned objectionable character to a marked degree, it was found that this quality was entirely lost after the tobacco had been extracted with petroleum ether. After evaporating off the petroleum ether from the extract the residue upon warming gave off fumes which were extremely pungent and irritating to the nose and throat. Upon examination these fumes were found to consist essentially of nicotine vapors. The nicotine is readily isolated from the extract by agitating the solution in petroleum ether with water containing sulphuric acid. The aqueous layer containing the nicotine is well washed with petroleum ether and after adding an excess of alkali to free the nicotine from the sulphuric acid is once more extracted with petroleum ether of very low boiling point or with ordinary ethyl ether. After evaporation of the ether from this extract the nicotine is left as a residue in almost pure condition. This residue retains all the pungency of the original extract, while the latter after removal of the nicotine no longer possesses this property.

A large sample of nicotine was purified by converting it into the citrate in aqueous solution and repeatedly extracting this solution with ether. The nicotine was then liberated with an excess of alkali, extracted from the aqueous layer with ether, and the ether solution dried. After evaporating the ether the nicotine was twice distilled in a current of hydrogen. The odor of this product was identical with that obtained by extracting the tobacco with petroleum ether, as already described. Although the peculiar sharpness or pungency of the smoke from tobacco of the kind in question is removed by extracting the tobacco with petroleum ether, and this quality is due to nicotine, all of the nicotine is not by any means removed in this treatment.

Kissling has studied the relative amounts of nicotine salts removed from samples of tobacco from several different sources by extraction with petroleum ether, with ordinary ether, and with alcohol. A certain definite portion of the nicotine, usually much less than half, is readily removed by extraction with petroleum ether, while further treatment with this solvent removes only traces of the remaining nicotine. It is perfectly clear, then, that nicotine is present in tobacco in at least two forms, one of which is soluble in petroleum ether while the other is practically insoluble.

Tobacco normally contains relatively large quantities of malic and citric acids, from 5 to 10 per cent, a portion of which is in combination with potash or lime and is of great importance in connection with the burning qualities of the leaf. Of these acids the portion above that required for combining with the lime and potash is doubtless largely combined with nicotine.

Nicotine, though quite volatile in the free state, is strongly basic and forms comparatively stable salts with acids which are not readily volatile. The nicotine salts of the difficultly volatile polybasic organic acids, such as malic, succinic, citric, and oxalic acids, are practically insoluble in petroleum ether; and, hence, the nicotine in combination with these acids would not be removed by extraction with this solvent. There seems to be no reason for supposing that freshly cured tobacco contains any of the volatile fatty acids, such as acetic and butyric acids, but it is well known that these acids are formed in the fermentation process from the malic and citric acids, or possibly more directly from succinic acid, which is itself formed by the fermentation of the citric and malic acids. Acetic acid, like nicotine, is easily volatile, and so nicotine acetate is also readily volatile. Moreover, this salt is readily soluble in petroleum ether. Ammonia is likewise a product of the fermentation of tobacco, and the small quantity of acetic acid formed in the fermentation of tobacco and which escapes volatilization is to be found in combination with either ammonia or nicotine.

Practically all tobaccos appear to contain more nicotine than is required for neutralizing all of the stronger organic acids which are not already in combination with mineral or inorganic bases. In other words, it appears that a portion of the nicotine contained in tobacco is present in practically a free state. It possibly does not exist in an absolutely free condition, but rather in loose combination with very weak acids of the order of tannic acid or those derived more directly from the splitting of the chlorophyll constituents. Such unstable salts would act in most respects like the free base. At any rate, the greater portion of the nicotine removed from tobacco by extraction with petroleum ether can be titrated with sulphuric acid directly, the same as if it were in the free state.

EFFECTS OF FERMENTATION AND AGING ON THE DIFFERENT FORMS OF NICOTINE IN TOBACCO.

It has long been known that there is a decided loss of nicotine in the fermentation process, and the amount varies from 10 to 15 per cent in the case of wrapper-leaf tobaccos to as much as a third of the total nicotine content in filler types. Different opinions have been advanced as to whether these losses are due principally to simple volatilization of the nicotine or to its decomposition. Those who have had experience in the packing house where the fermentation is carried on do not need to be reminded of the sharp, disagreeable, and often nauseating odor emitted from the fermenting bulks, and this characteristic odor is due principally to the volatilization of the nicotine. This volatilization of the nicotine is not confined to the fermentation, but is marked throughout both the air-curing and the flue-curing processes. Now it can be very readily demonstrated that there is practically no volatilization of nicotine when combined with malic or citric acids even at the highest temperatures reached in the fermentation bulks or in the curing barn in the flue-curing process. Of course this statement would not apply to the portion of these salts in which the acid constituents undergo fermentation, forming volatile fatty acids.

Since the nicotine salts of malic and citric acids are insoluble in petroleum ether, it is very instructive to compare the amounts of nicotine removed by extraction with this solvent before and after fermentation. The following table shows the percentage of nicotine soluble in petroleum ether before and after fermentation, as well as the loss of this base in the fermentation process, in the case of a sample of Connecticut shade-grown wrapper-leaf tobacco:

TABLE I.—*Nicotine soluble in petroleum ether in a sample of Connecticut wrapper-leaf tobacco before and after fermentation.*

	Per cent.
Total nicotine before fermentation	3.39
Total nicotine after fermentation	2.89
Loss of nicotine in the fermentation process	0.50
Nicotine soluble in petroleum ether before fermentation	1.60
Nicotine soluble in petroleum ether after fermentation	1.01
Difference	0.59

It will be seen that the total loss of nicotine in fermentation corresponds very closely to the difference between the amounts soluble in petroleum ether before and after the fermentation, and it is highly probable that nearly all of this loss is due to simple volatilization. As is to be expected, the loss of nicotine is greatest in those cases in which the temperatures of the fermenting bulks reach the highest points. This volatilization of nicotine which takes place during the curing, and especially in the fermentation process, continues throughout the subsequent aging of the tobacco, but of course at a diminished rate. It is easy to understand, therefore, the marked improvement brought about by resweating or a long period of aging in the case of those types of tobacco containing excessive quantities of nicotine in an easily volatile form, which imparts a very undesirable sharpness ungency to the smoke.

In addition to these marked losses of nicotine by simple volatilization, there is a further decrease brought about by a process of oxidation. This latter transformation is a very slow one, and while it plays a part in the production of the brown color of tobacco it is not of importance as regards the total nicotine content. The slow oxidation of the nicotine to thick, brown-colored, tarry substances begins in the curing shed and is a continuous process thereafter, affecting alike the difficultly volatile and the easily volatile forms.

EFFECTS OF ORGANIC ACIDS ON THE NICOTINE CONTENT OF TOBACCO.

It has already been pointed out that, while the true physiological effect produced by the smoke of a given sample of tobacco depends essentially on the total nicotine content, one important factor pertaining to the strength of the tobacco as this term is generally understood—i. e., the sharpness of the smoke—is the amount of the nicotine present which acts as if it were in the free state in that it is readily volatile. Furthermore, it has been shown that this easily volatile form of the nicotine is readily soluble in petroleum ether, while the nicotine which is in combination with malic and citric acids is not soluble. It follows, therefore, that the sharpness shown by the smoke of any tobacco should be removed either by extracting the tobacco with petroleum ether or, equally as well, by adding a sufficient quantity of malic or citric acid to combine with all the nicotine present.

We have made a number of experiments along this line with a sample of domestic filler tobacco which was especially well adapted for this purpose, and the results appear to justify fully the above conclusions. This tobacco was of excellent quality in nearly every respect except that the smoke was extremely sharp and pungent, so that it was necessary to blend the tobacco with some other very mild type before using it for the manufacture of cigars. This filler was classed as a strong, very heavy type, although the total nicotine content was only 2.20 per cent, while many of our domestic filler types contain as much as 5 per cent of nicotine. The amount of this nicotine soluble in petroleum ether was determined. To a portion of the tobacco about 2 per cent of citric acid was added in aqueous solution by spraying, after which the sample was cased down for two days to allow the citric acid to diffuse through the leaf as far as possible. The nicotine in this sample before and after extraction with petroleum ether was then determined. For comparison, a sample of imported Cuban filler known as "Santa Clara," which is a very mild type and which showed only a slight sharpness in the smoke, was also tested as to the amount of nicotine soluble in petroleum ether.

The results of these tests are shown in the following table:

TABLE II.—*Nicotine soluble in petroleum ether in domestic filler tobacco before and after the addition of citric acid.*

Nicotine content.	Domestic filler tobacco.	Domestic filler tobacco, with citric acid added.	Imported Cuban Santa Clara tobacco.
	Per cent.	*Per cent.*	*Per cent.*
Total nicotine	2.20	2.13	1.33
Nicotine insoluble in petroleum ether	0.76	1.66	0.79
"Free" nicotine	1.44	0.47	0.54

It will be observed that two-thirds of the total nicotine contained in the domestic filler tobacco is in the easily volatile form which exists either in the free state or loosely combined with weak acids and that the addition of citric acid renders the greater portion of this insoluble in petroleum ether. The fact that the nicotine is not made wholly insoluble by the addition of the acid is accounted for partly by reason of the slight solubility of the nicotine citrate in petroleum ether, but mainly because the solution of citric acid added had not diffused throughout the leaf tissue. Better results could be obtained by adding the citric acid solution before the fermentation process is completed, thereby affording a better opportunity for the even diffusion of the acid through the leaf. Even under these unfavorable conditions the soluble portion of the nicotine was reduced below that of the mild Santa Clara sample.

Samples of this tobacco to which the citric acid had been added were made into cigars which were tested by a number of persons, and the universal opinion has been that the sharpness or pungency of the smoke has been almost entirely removed by this treatment. Other similar acids, such as malic and tartaric acids, are also efficient in overcoming this property of the smoke, but oxalic acid does not give satisfactory results. The easily volatile fatty acids, such as acetic acid, form easily volatile salts with nicotine and hence do not produce any decided influence in this respect. It has already been stated, moreover, that these salts are soluble in petroleum ether.

Citric and malic, succinic, and finally acetic and butyric acids merely represent intermediate stages in the degradation by fermentative processes of the sugars to carbon dioxid and water. Citric and malic acids exist in the leaf prior to the fermentation, and whether the quantity of these is diminished in this process depends in any given case on whether the loss occasioned by partial transformation of these into succinic, butyric, and acetic acids is made good by the formation of further quantities by fermentation of the sugars. Acetic acid is formed during the fermentation at the expense of the citric and malic acids, and hence it follows that prolonged fermentation can never entirely remove the pungency of tobacco smoke due to the easily volatile nicotine. In the presence of an excess of citric acid, however, the greater portion of the acetic acid would be expelled because of its easy volatility.

Citric acid is a normal and valuable constituent of tobacco, and its addition in moderate amounts could not therefore injure the quality of the tobacco in any way. There is every reason to believe that its addition during the fermentation process would prove highly beneficial to those types of cigar-filler tobacco which contain excessive quantities of nicotine not already in combination with citric or malic acids. This could probably be best applied by spraying the tobacco at the time of turning the bulks with an aqueous solution of such concentration as to add from 1 to 2 per cent of the acid.

COMPOSITION OF TOBACCO SMOKE.

Now that we have seen that organic acids like citric, malic, or tartaric acid are efficient agents in preventing the nicotine contained in the tobacco from imparting an undesirable sharpness to the smoke, the question naturally arises as to the manner in which these acids effect this result. There would seem to be three possible ways in which this effect might be produced: (1) The nicotine salts of these acids are so difficultly volatile that the nicotine is decomposed in situ by the heat from the burning end of the cigar; (2) these salts, on account of their slight volatility at lower temperatures, are condensed from the smoke before it enters the mouth of the smoker and thus constantly accumulate in the unburned portion of the cigar; and (3) the nicotine passes into the smoke and enters the mouth of the smoker in the form of the salt instead of in the free state, thus losing its pungency or biting qualities. Which of these alternatives affords the true explanation can best be answered by smoking the tobacco in a suitable apparatus and determining the amount of the nicotine contained in the smoke and that remaining in the unsmoked ends of the cigars.

A number of investigators have endeavored to study the composition of tobacco smoke, but the problem presents many difficulties in the matter of securing satisfactory analyses. Without attempting to enter into this subject fully, it may be said in brief that the smoke is, in the first place, mixed with large amounts of nitrogen and small quantities of oxygen derived from the air used in the combustion. In addition to these, the smoke proper contains, as difficultly condensible gases, small but appreciable quantities of carbon monoxid, hydrocyanic acid, and probably also hydrogen sulphid. These latter are three well-known poisonous gases, although the quantities contained in tobacco smoke are probably too small to be of any special significance. Among the more easily condensible constituents may be mentioned nicotine and its decomposition products, especially pyridin, an ethereal oil of fragrant odor and a complex mixture of thick, tarry substances. Of course the smoke also contains large quantities of carbon dioxid and water vapor resulting from the combustion of the tobacco. The nicotine content of tobacco smoke has been extensively studied by Kissling,[a] whose principal conclusions may be briefly summarized as follows: Considerably less than half of the total quantity of nicotine is ordinarily destroyed in the smoking of a cigar, and greater or lesser quantities enter into the smoke, depending on what portion of the cigar remains unsmoked. In the case of a lot of cigars containing 3.75 per cent of nicotine, when two-thirds of the entire cigar were smoked about 28 per cent of the nicotine in the smoked part of the cigar was contained in the smoke; about 12 per cent had accumulated in the unburned portion of the cigar, and about 60 per cent was destroyed. In another experiment in which nearly seven-eighths of the entire cigar were smoked, the percentages were 52, 5.5, and 42.5, respectively. Unfortunately, in these tests the cigars were smoked by drawing through them a constant flow of air instead of by intermittent "puffs,"[b] as in the actual practice of smoking, so that the above values are not entirely applicable. Kissling considers that the physiological effects of tobacco smoke are produced almost wholly by nicotine and its immediate decomposition products of the pyridin class of compounds.

We have carried out several experiments along the lines of those conducted by Kissling to determine more particularly the effects produced by citric acid on the nicotine content of tobacco smoke. A portion of the sample of tobacco repeatedly referred to in this paper was sprayed with an aqueous solution of citric acid in the manner already described, and was then made into cigars. Another portion of the same sample without the addition of the acid was also made into cigars. A like number of each was smoked in a suitable apparatus, the smoke being drawn through a series of flasks containing sulphuric acid to absorb the nicotine. The wash waters containing the nicotine from the smoke were then distilled in a current of steam to remove any indifferent volatile matter, an excess of alkali added, and the mixture was then again distilled. The distillate containing the nicotine mixed with pyridin and a relatively large amount of ammonia was accurately neutralized with sulphuric acid and then evaporated to dryness. The nicotine and pyridin were then separated from the ammonia by extracting the residue with small volumes of absolute alcohol. The apparatus used for smoking the cigars was so constructed that the air could be drawn through the cigars either in an uninterrupted current or intermittently, and the rate of smoking was so regulated that about thirty minutes would be required for the complete combustion of a cigar. In one series of experiments approximately two-thirds of each cigar were smoked, while in a second series only one-half of each was consumed. The results obtained are recorded in Table III, but it is to be understood that the values shown are only approximate, since they are influenced by a multitude of factors which can not be rigidly controlled. In experiments 1 and 3 the cigars were smoked by intermittent "puffs," while in experiments 2 and 4 they were smoked by a constant current of air. In every case the results given in the columns designated by "A" refer to cigars made of tobacco to which citric acid had been added, while those under columns headed "B" refer to cigars from the natural leaf. All results are expressed in percentages and are the averages obtained from smoking a number of cigars. The cigars used contained 2.2 per cent of nicotine. The percentages of nicotine given in the table are all calculated to the amount of nicotine in the portion of the cigar actually smoked, and not to that contained in the whole cigar. The values for nicotine include at least a portion of the pyridin formed by the partial decomposition of the nicotine, inasmuch as no method has been devised for the quantitative separation of these two substances.

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[a] Dingl. Polyt. Journal, 1882, p. 64.

[b] The word "puff" in this paper is used to cover both the inhalation and expulsion of the smoke.

TABLE III.—*Nicotine in the smoke of cigars made from tobacco to which citric acid had been added and those made from natural leaf.*

	Experiment 1.		Experiment 2.		Experiment 3.		Experiment 4.	
	A.	B.	A.	B.	A.	B.	A.	B.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Portion of total weight of cigars smoked	73	70	60	63	49	50	48	51
Nicotine of smoked tobacco found in smoke	25.5	34.5	27	31.5	....	....	22	26.8
Nicotine of smoked tobacco recovered from residual ends	14	8	54	42	29	18	48	40
Nicotine destroyed in process of smoking or expelled directly into the air from the burning end of the cigar	60.5	57.5	19	26.5	....	....	30	33.7

It will be seen that when about two-thirds of a cigar are smoked about 30 per cent of the nicotine of the smoked portion passes into the smoke, while from 10 to 20 per cent collects in the unsmoked portion, and the remainder is either destroyed or escapes into the air. The striking increase in the amount of nicotine which collects in the unsmoked portion of the cigar when it is smoked by means of a constant current of air instead of by intermittent "puffs" is due to the circumstance that in the first case practically all of the nicotine is drawn into, or through, the unburned portion of the cigar, while in the latter case a large portion of the nicotine escapes into the air during the intervals between "puffs." The relative amount of nicotine which is to be found in the smoke depends chiefly on the relative length of the unsmoked portion of the cigar and on the rate at which the smoke is drawn through the cigar.

The point of chief interest, however, is the effect of the citric acid on the nicotine content of the smoke. It is apparent that in every case the quantity of nicotine in the smoke is reduced, while that which collects in the residual end of the cigar is correspondingly increased. This difference, nevertheless, is too small to account for the marked effect produced on the quality of the smoke. Apparently the only possible explanation of this pronounced effect on the sharpness of the smoke is that in the presence of the citric acid the nicotine enters the smoke in the form of a salt rather than in the free state, and thereby loses its pungency while still exerting the usual physiological effect.

CONCLUSIONS.

It has been shown in the preceding pages that there is no direct relation between the so-called "strength" of tobacco when used for smoking purposes and the total content of nicotine. However, a distinction must be drawn between two forms of nicotine contained in tobacco, one of which is easily volatile and readily soluble in petroleum ether while the other is volatile only at elevated temperatures and is almost insoluble in petroleum ether. The undesirable sharpness or pungency contained in the smoke from certain types of cigar-filler tobacco and which constitutes one of the two factors included in the term "strength" as applied to the smoke is due almost entirely to the volatile, easily soluble form of nicotine which acts as if it were in the free state. On the other hand, the true physiological effects of the smoke, as embodied in the term "fullness," are proportional to the total quantity of nicotine.

The pungent, harsh quality of the smoke is partially, but not entirely, removed by protracted resweating and aging of the tobacco, whereby the easily volatile nicotine is largely expelled. This undesirable property is entirely removed by extracting the tobacco with petroleum ether, which simply dissolves out the volatile nicotine. Finally, the addition of sufficient citric acid to the tobacco to combine with all of this easily volatile nicotine efficiently overcomes the sharpness or pungency of the smoke. It can best be added by spraying the tobacco with an aqueous solution when the fermenting bulks are being turned. The addition of the citric acid reduces somewhat the amount of nicotine in the smoke of the cigar, but not enough to account for the marked effect on the quality of the smoke. It is suggested, therefore, that probably the nicotine enters the smoke in the form of a salt rather than in the free state, thereby losing its pungency.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 141, PART II.

B. T. GALLOWAY, *Chief of Bureau.*

UNIV. OF MICH.
NOV 16 1908

THE GRANVILLE TOBACCO WILT.

BY

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ISSUED AUGUST 31, 1908.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1908.

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THE GRANVILLE TOBACCO WILT.

By Erwin F. Smith,

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HISTORY.

Attention was first called to the Granville tobacco wilt in September, 1903, by McKenney, then connected with this Department. He attributed it to a fungus (Fusarium) nearly related to those studied by the writer on cotton, melon, and cowpea. No proofs from inoculation were obtained by McKenney.

A few days after the appearance of McKenney's paper a bulletin was published by Stevens and Sackett, of the North Carolina Agricultural Experiment Station, describing this disease and attributing it to bacteria. Their diagnosis also depended solely on field observations and microscopic studies, but this part of the work was well done.

In 1905, as the result of personal examinations of infected plants, studies of the microorganism in pure cultures, and successful inoculations therefrom, the writer confirmed the findings of Stevens and Sackett as to the bacterial nature of this disease. Numerous successful infections of tobacco were obtained both by needle puncture from pure culture and by plantings in infected soil.

The organism was identified provisionally as closely related to *Bacterium solanacearum*, a species described by the writer in 1896 as the cause of a widespread and destructive brown rot of the potato, tomato, and eggplant. This conclusion was based on the similar behavior of the tobacco bacterium and of undoubted *Bacterium solanacearum* (derived from tomato and potato) in a variety of culture media. The shade of doubt remaining in my mind at that time was due to the fact that many cross-inoculations (potato to tobacco and tobacco to tomato), while showing multiplication of bacteria in the inoculated tissues and some other signs of disease (brown stain in the bundles, and on tomato stems the development of incipient aerial roots), did not contract the wilt.

THE CONTINUED PREVALENCE OF THE DISEASE.

Both in North Carolina and in Florida this wilt of tobacco has continued with increasing severity, the losses in 1908 being greater than those of any previous year. In North Carolina quite a number of planters have lost whole fields and others considerable parts of fields. Still others have harvested their tobacco green to save some part of it. The entire loss in 1908 in North Carolina is not known, but is estimated at upwards of $100,000.

In Florida the disease has also made great inroads in several places, causing serious losses for three or four years. In 1908, one man lost 20 acres of tobacco under shade by reason of it. The same year a company lost nearly every plant on 12 acres of home-grown Sumatra under shade and also a considerable part of 95 acres of imported Sumatra, also grown under cover (cloth). On many of these fields tobacco has followed tobacco for a long series of years (eighteen years in one field).

The worst feature of this disease is the fact that fields once infected remain infected indefinitely, or at least for many years, and are also useless for growing any other plant of this family, e. g., potatoes, tomatoes, eggplants, or peppers. The disease is therefore a very serious one. If it continues at its present rate of progress, tobacco growing in the infected districts will become impossible within a few years, and if it should extend to all the tobacco-growing sections of the United States this industry would be destroyed. It is therefore of the utmost importance to keep it out of sections which are still free from it. To this end correct information respecting its nature should be disseminated as widely as possible. An ounce of prevention is worth tons of cure—and, moreover, *a cure* is not in sight. Something may be done, however, by good field hygiene to restrict its progress.

BACTERIAL ORIGIN OF THE DISEASE.

The writer no longer has any doubt as to the bacterial origin of this disease. On two or three occasions he has found Fusarium on tobacco stems affected by this disease, but not commonly, nor ever exclusively. Generally there were also a great many bacteria present in the stems occupied by the fungus. Once I have observed Fusarium to be a secondary infection—in one plant out of many inoculated with the bacterium some years ago.

Almost all of the diseased tobacco plants examined by me from North Carolina and from Florida, a hundred or more, in several different years, were attacked by bacteria to the exclusion of fungi. Fusarium certainly was not present. Nothing here said, however, need be construed as a denial of the occurrence in this country of a Fusarium disease of tobacco, since it is very reasonable to suppose the existence of such a disease. There are many such diseases, as the writer was the first to point out. One occurs on the tomato and another on the potato. Why not one on tobacco? The evidence necessary to establish such a contention, however, is yet to be procured. Meanwhile we may consider the Granville wilt as solely bacterial in its origin.

NEW EXPERIMENTS.

Experiments by the writer in the summer of 1908 have demonstrated that the Carolina tobacco disease is readily communicated to tomatoes through the root system. These infections were obtained by transplanting healthy tomatoes into a bed of good hothouse soil in which tobacco plants affected by the Granville wilt had been buried recently. The stems of these tobacco plants, which were obtained from North Carolina, were swarming with the bacteria peculiar to this disease. The tomato plants were infected through *broken roots,* the plants being of considerable size when set into the infected bed.

The experiment was begun at the end of July, and up to this date (August 18) nineteen tomato plants have contracted the disease. This disease is typical tomato wilt, the vascular bundles of stems and midribs being browned and their vessels filled with the grayish white bacterial slime peculiar to the genuine tomato disease. Dissections showed the brown stain and the bacteria in the bundles to be more abundant as one passed from the top of the plant toward the roots, and always one or more broken roots were found *diseased to their very end,* i. e., browned and occupied by the bacteria. Most of the roots, however, as well as all of the underground stem and all of the parts above ground, were free from external appearance of disease other than the wilt, i. e., from wounds, spots, or stains. The wilting was sudden, i. e., not preceded by any yellowing of the foliage. Numerous incipient roots developed on the stems. No other tomato plants in the houses or on the grounds (several hundred) showed any signs of this disease.

The Jimson weed (*Datura stramonium*) planted in this bed also contracted this disease through the root system.

Moreover, with bacterial slime taken from the interior of four of these wilting tomato plants (upper part of the stem) I have caused the Granville tobacco wilt inside of two weeks on four large healthy tobacco plants, the bacteria being introduced into leaves and stems by means of needle pricks, and also by pulling off leaves and rubbing the scars with the crushed tomato stems. The signs of this tobacco disease so obtained were in every way characteristic—wilt of foliage, darkening of the veins of the leaves, longitudinal dark stripes on the stem originating from internal staining, brown stain of the vascular bundles of the stem and leaves, and vessels gorged with the characteristic bacteria. Some of the uninoculated leaves also dried out irregularly, and the apical leaves on the inoculated side of the stem became dwarfed and distorted. The inoculations were made in another hothouse (where no other Solanaceae were grown), the checks remained healthy, and when the wilting plants were cut for examination the root system in three of the four plants was still free from disease, the inoculations having been made at the top of the plants. Moreover, in all cases (four places on each plant) the disease began in the pricked and rubbed areas.

SPECIFIC GERM INVOLVED.

The cultural characters of the tobacco organism are the same as those of *Bacterium solanacearum* derived from tomato or potato, and now that good cross-infections have been obtained no doubt remains that the Granville wilt of tobacco and the brown-rot of potato, tomato, and eggplant are one and the same disease, i. e., due to the same organism, all of these plants belonging to the nightshade family and being rather close relatives. The Florida tobacco wilt at Quincy and Hinson appears to be the same thing. I examined diseased plants from Florida some years ago and again this year.

The writer formerly stated (1896) that he did not succeed in cross-inoculating *Bacterium solanacearum* into tobacco and peppers, and at that time he believed tobacco to be exempt, but not many experiments were made, and we may assume either that the cultures used had lost their virulence or that the particular plants selected were too old or growing too slowly, or for some other reason were unusually resistant. The writer now believes that *Bacterium solanacearum* does frequently lose its virulence by continued culture; that, in general, old and slow-growing plants are difficult to infect; and that some individuals and some varieties are more resistant than others. This, I believe, sufficiently explains the former failures. We may conclude, therefore, in searching for remedies that we have one disease to deal with and not several.

METHOD OF ENTRANCE OF THE BACTERIUM.

If stomatal infections occur, which is not unlikely, especially in wet weather, they have not yet been demonstrated. So far as we know, this organism enters the plant only through wounds. Van Breda de Haan found the root system especially subject. Stevens and Sackett state that the infection is first in the root. A large number of infections undoubtedly take place under ground, the organism present in the soil entering the plant through wounds made in transplanting or cultivating, or by small animals infesting the soil. Roots broken in transplanting and leaves pulled or pinched off at that time are responsible for many infections, and it would seem that by care the number of such wounds inviting infection might be greatly reduced.

It has been observed in Sumatra, where occurs a destructive bacterial wilt some years ago identified by Hunger as due to *Bacterium solanacearum*, that the tobacco plants are peculiarly subject to it when grown on land infested with eelworms (nematodes) or with insects which attack the roots or base of the stems. Rainy weather is favorable to the progress of this disease, although the wilt may be detected first in dry weather. In this country it has been observed, especially by Earle on tomatoes in Alabama, that wet soil is peculiarly favorable to the spread of this disease. All observers agree that the root system is peculiarly liable to attack. To a very considerable extent the destructive prevalence of this disease seems to hinge on the occurrence of root-infesting nematodes. They are common in the diseased tobacco soils of Florida and probably occur also in those of North Carolina.

REMEDIES AND PALLIATIVES.

(1) This organism is to be regarded as a very bad weed liable to be distributed in many ways. It is worse than ordinary weeds because it is invisible. On plantations free from the disease a rigid quarantine should be erected against plantations subject to the disease: Nothing should be received by the farmer from the latter—seeds, young plants, raw tobacco, cured tobacco, packing cases, wagons, tools, fertilizers, laborers, horses, cattle, etc., all should be excluded. Avoid also the manuring of fields with tobacco waste even when it is believed to originate from clean sources.

(2) Do not plant tobacco on lands subject to this disease. Rent healthy land at a distance if necessary. To plant infected land invites disaster. *It is not safe to do so even after several years.* Stevens and Sackett have recorded several cases where the disease returned after five to eight years rest of the soil, and one instance where it did not return after a rest of fifteen years.

(3) Do not cultivate any other similar plants on infected land. Tomatoes, potatoes, eggplants, peppers, and pepinos are all more or less subject to this disease, and their growth will help to continue the organisms in the soil. Grow plants of some entirely different family. Look out also for Solanaceous weeds. It is not known whether these are actual harborers of the bacteria, but it is well to destroy them. In the hothouse the writer has found the plant called Stramonium, jimpson, or Jamestown weed quite subject to this disease. The disease is also readily inoculable into the black nightshade *(Solanum nigrum).*

(4) Search the affected tobacco fields carefully, especially toward the end of the season, in the hope of finding resistant plants from which seed may be saved for the breeding up of resistant sorts. There is some hope that this may be accomplished. The intelligent planter can serve himself in this matter as well as help to excite general interest in the subject. The end in view is worth the expenditure of much time and trouble.

(5) If it is impossible to avoid the use of infected lands, then certainly avoid planting the wettest spots, and underdrain such fields as speedily as possible.

(6) Select for the seed beds soil which is uncontaminated, and transplant to the field *early*, i. e., while the plants are quite small, *and with the greatest care to avoid breaking the roots.* Cultivate shallow with the same thought in mind. Under no circumstances use large plants

on such lands. The roots are certain to be broken more or less in transplanting and equally certain to become infected, with subsequent infection of the whole plant. Probably half the trouble on such lands, if they are free from nematodes, might be avoided by careful attention to this one particular. Under tents, sowing the seed in the place where the plant is to stand might also be given a trial.

(7) Wound as little as possible the base of the plants and the tops by pruning or pulling away leaves. Do not jerk off leaves when setting out. It is a good rule under ordinary circumstances to balance root and top by removing a portion of the leaves at planting time, ***but not when this disease is present***, since infection is liable to occur in this way. The same end may be accomplished with less danger to the plants by using greater care in transplanting, and especially by transplanting when the plants are small. Top the plants in dry weather.

(8) Avoid fields known to be infected with root nematodes. They wound the roots and enable the bacteria to gain an entrance. Hunger demonstrated this on tomatoes in the Dutch East Indies. If such fields must be used, the nematodes may be reduced in number by rotation with winter grains (oats, rye, wheat) followed by velvet beans but not by cowpeas (except Iron), since ordinary cowpeas are much subject to root nematodes and will increase the number of them in the soil. Velvet beans are not subject to nematodes. The number of nematodes in the soil may also be reduced by a skillful use of trap crops, but an unskillful use of the same will increase their number. The object of a trap crop is to get as many nematodes as possible encysted in the roots, which are then pulled up and burned. Cowpeas may be used as a trap crop. They should be removed and burned as early as the fourth week, i. e., before the nematodes have escaped again into the soil in increased numbers. It would be best, however, to put this work into the hands of persons having some knowledge of biology, since trap-cropping for nematodes is still in the experimental stage.

(9) Remove and burn affected plants as soon as they are detected. They are swarming with innumerable millions of infectious particles[1] which plowed under or allowed to fall to the ground are washed into the earth and will serve to increase the soil infection. Such plants are also a source of danger to your own free fields and to those of your neighbors. There are enough neglected tobacco plants in Granville County to infect the whole United States if properly distributed.

(10) Under no circumstances throw tobacco refuse on your fields, or into your barnyard, or into streams or roadways. Such refuse is a good fertilizer, but it may also prove the carrier of this disease and the danger is too great. The organism may live in the dead stems for some time—just how long is not known. Do not take any risks. The

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[1] A single tobacco plant may contain ten thousand million of these bacteria.

organism is not known to produce spores and is believed to be destroyed by a short exposure (ten minutes) to 52° C. (125° F.), but until it has been confirmed on a large scale in the field it is best to be cautious about using waste material from the curing house. Some portion of it containing these bacteria may not have been heated hot enough to destroy them.

(11) Strive to keep uninfected fields free from infection. To this end look out for the tobacco refuse; also for wash of rain water from infected lands (this to be turned aside by ditches and dikes). Be watchful also for other sources of infection, e. g., dirt or fragments of infected tobacco carried on tools, feet of horses and cattle, etc.

Tools may be disinfected (after removing the dirt) by a short exposure to live steam, boiling water, or the open flame (gasoline torch). Five minutes exposure ought to be ample. They may also be disinfected by the use of germicides, e. g., 5 per cent carbolic acid (poison) or one-fifth per cent mercuric chlorid (poison). Carbolic acid or mercuric chlorid (corrosive sublimate) are better than formalin, since the latter is volatile and likely to be under the certified strength (40 per cent formaldehyde) in broken packages or old corked bottles. Mercuric chlorid tablets prepared for this purpose, so that weighing is not necessary, are on the market. Wooden pails and clean boiled water should be used. The germicidal action of mercuric chlorid is destroyed by contact with metal dishes. These substances should be kept out of reach of children.

(12) Avoid also the increasingly common southern practice of sowing fields with dirt from other fields, the idea being to inoculate the soil with nitrogen-fixing organisms. This method of inoculating soils is a bad practice under any circumstances, i. e., one well calculated to disseminate plant parasites and one particularly reprehensible in localities where this disease prevails or is liable to occur. Nematodes, injurious insects, parasitic fungi, club-root of cabbage and other Crucifers, and plant-destroying bacteria, not to mention animal parasites, are all liable to be disseminated in this way. To let loose a whole menagerie for the sake of obtaining an ox or an ass is not a good policy. Obtain pure cultures for soil inoculations from the Department of Agriculture or the State Agricultural Experiment Station.

(13) Those who grow Sumatra wrapper-leaf tobacco under tents erected at great expense and whose annual crop is worth $1,000 or $1,500 per acre can afford greater expenditures in combating this disease than the ordinary planter. Such persons should endeavor to free the soil of this organism by fire or by steam heat. They should also combat the nematodes. *Bact. solanacearum* is quite sensitive to heat, and if the whole body of the soil could be warmed up to 125° F. for fifteen minutes this organism would be destroyed. If such attempts are made great care must be taken that the sterilized portions are not

reinfected by careless workmen from the parts not yet treated. Live steam under considerable pressure conveyed through parallel lines of buried gas pipes and let loose into the soil at short distances by suitable *small* openings is probably the best method of applying steam. It may be applied, however, as Shamel has recommended for seed beds, i. e., under large shallow metal pans, which are then moved to a fresh portion of the field, and so on until all is treated. A lettuce grower in Boston has invented a sort of drag-tooth device of gas pipe which is driven down into the soil and steam turned on for a half hour or more. This is then lifted and driven down in another place, and so on until the whole bed is covered. It effectually sterilizes the soil, but the labor is very considerable.

(14) Get your neighbors to unite with you in carrying out these measures.

RECAPITULATION.

The tobacco wilt is due to bacteria. They occur in the diseased plants in enormous numbers. They infest the soil and remain alive in it a long time. The plants are commonly infected through injuries due to nematodes (eelworms) which cause swellings on the roots, or through roots broken in setting out. Late transplanting from the seed bed is very disastrous when this microorganism is in the soil. Potatoes, tomatoes, eggplants, and other members of the nightshade family are also subject to this disease.

Sound plants depend on planting in uninfected land. To keep uninfected fields free and to reduce the amount of infectious material in diseased fields, remove and burn the diseased plants and practice the other hygienic measures here recommended.

Immediate remedial measures should look to reducing the number of nematodes in the soil; to greater care in transplanting, so that the plants, and more particularly the roots, shall not be wounded; and under tents, if the cost is not prohibitive, to destruction of the bacteria by steam heat.

Remote remedial measures should look to breeding up races of tobacco which shall be resistant to this disease either directly, or indirectly by being resistant to root nematodes.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 141, PART III.

B. T. GALLOWAY, *Chief of Bureau.*

GE
UNIV. OF MICH.
JUL 9 1909

THE FLORIDA VELVET BEAN AND ITS HISTORY.

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ISSUED MAY 19, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

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B. P. I.—463.

THE FLORIDA VELVET BEAN AND ITS HISTORY.

By KATHERINE STEPHENS BORT, *Laboratory Aid, Forage Crop Investigations.*

HISTORY OF THE FLORIDA VELVET BEAN.

The most important leguminous forage crop grown in Florida is undoubtedly the velvet bean. In the past fifteen years it has rapidly grown in importance as its value has come to be more and more appreciated. In so far as one can rely on the memory of various residents in Florida, the velvet bean was known there at least as early as 1875, but no documentary evidence earlier than 1890 has been found. In connection with the study of the Florida velvet bean the interesting fact develops that the plant does not belong to any of the species to which it has been referred, but on the contrary is a distinct species not heretofore properly characterized or named. The detailed history of the plant as far as the documentary or published evidence is concerned is given below.

On September 8, 1890, Hon. J. M. Rusk, Secretary of Agriculture, writing to Mr. S. C. Carleton, Argo, Fla., in a letter preserved in the files of the United States National Herbarium, acknowledges the receipt of " a peculiar seed of a bean," and continues the letter as follows:

> The plant is apparently a species of the genus Mucuna. The National Herbarium contains nothing exactly like it and it is probably of tropical origin. I shall be glad if you will send us some specimens of the vine, portions of the stem a foot or two long with some flowers, leaves, and fruit in position. We wish to prepare the specimens for permanent keeping in the herbarium. I mail you to-day a box in which the plant can be placed and sent free of postage.

No further correspondence has been found, but in the United States National Herbarium are several specimens sent in by Mr. Carleton under date of September 22, 1890, on one of which is the information "introduced with coffee seed," and on another " introduced from tropical America of West Indies." These specimens were mistakenly identified as *Mucuna pruriens* L. The plant is the Florida velvet bean, and the above is the first documentary record concerning it that has yet been found.

In Bulletin No. 35 of the Florida Agricultural Experiment Station, published in April, 1896, Mr. O. Clute writes as follows:

> Early in 1895 my attention was called to a "pea" which was reported to grow luxuriantly in poor soil, to give a large amount of forage, to yield an unusual amount of peas, and to be eaten readily, both forage and peas, by all stock. The gentleman who reported this pea has no name for it. Afterwards the same plant was found in Lake City and in other places in Florida, grown as an ornamental on trellises for shading piazzas, under the name of velvet bean. * * * It began to bloom in August, producing long clusters or racemes of somewhat large purple flowers, which were quite ornamental. The bloom was followed by plump pods of rich, dark green, covered with a close down, like velvet, whence probably comes the name of "velvet bean." * * * I have not been able to learn the botanical name of the plant. Probably it was introduced as an ornamental climber. It may have come years ago from the Patent Office, or more recently from the Department of Agriculture. * * * Mr. A. P. Newheart, of Ocoee, Fla., of whom I obtained the seed planted at the station at Lake City, called the plant a pea. He writes as follows: "Your letter is at hand. At your request I will state that I know nothing of the origin of the pea, and can find no one among the old settlers that has the least knowledge where the pea came from. It has been planted here some twenty years, solely as coverings for trellises and unsightly places."

In December of the same year that Mr. Clute published his bulletin, Mr. Gerald McCarthy, in Bulletin No. 133 of the North Carolina Agricultural Experiment Station, has this note:

> BANANA OR VELVET PEA.—*Dolichos multiflorus* (Plate I).—The banana pea is not a true cowpea, though closely related. Its botanical name is *Dolichos multiflorus*, and it is a native of the southern part of Florida, extending southward into the Tropics. This pea is much more tender as regards cold than the common cowpea, and this, with its extremely long season of growth, reduces very considerably its agricultural value for North Carolina and colder States. The seeds are large, roundish, granite color, and speckled like the common "speckled" pea. The growth of vine is enormous, far exceeding any other legume known to agriculture, reaching 20 to 30 feet.

The identification of the Florida velvet bean as *Dolichos multiflorus* Torr. (*Dioclea boykinii* Gray) is clearly erroneous. That plant is native in Florida and is very different from the velvet bean.

Since 1896 there have been frequent press notices of the velvet bean. Some of the more important, as throwing light on its history, are the following:

> Seven years ago only two grove men here had planted the velvet bean; from these the acreage planted in orange groves gradually increased until last year there were about 25 orange groves planted to the velvet bean. The results were so favorable that fully 300 orange growers planted the bean for fertilizer alone this year.—*Florida Farmer and Fruit Grower (Jacksonville, Fla.), November 27, 1897, p. 757.*

> Although notes on this plant have already appeared in the Queensland Agricultural Journal for August and October, 1897, I think that the following infor-

mation respecting its growth in this colony may be of interest to Queenslanders, as the previous notes were simply extracts from American journals, and the information they gave more applicable to American than to Queensland conditions.

In the first place, the plant has been wrongly named, as it is not *Dolichos multiflorus*, but is recognized by Mr. F. M. Bailey, to whom I submitted specimens, as *Mucuna pruriens*, var. *utilis*, a variety of the plant commonly known as "Cowhage" or "Cow-itch." The description already given of this plant is substantially correct, so I will simply refer my readers to the illustration herewith,[a] which has been drawn by the artist to the department from a plant grown[b] at the Redland Bay Experiment Farm.—*Albert H. Benson in Queensland Agricultural Journal, May, 1898, p. 370.*

VELVET BEAN (*Mucuna utilis*).—Annual; climbing; stems sometimes 50 feet in length; leaflets 3, large; pods numerous, 2 to 3 inches long, each containing three or four large oval beans.

A newly introduced plant which has not been extensively tested, but which has been highly recommended by the experiment stations of Louisiana and Florida.—*United States Department of Agriculture, Division of Agrostology, Bulletin No. 15, "A Report Upon the Forage Plants and Forage Resources of the Gulf States," by S. M. Tracy. July 15, 1898.*

FLORIDA VELVET BEAN.—Under this name a leguminous plant has been prominently recommended in American journals as a forage plant and as admirably adapted for green crop manuring. Recently the beans have been offered for sale in this country. As frequent references have been made to Kew, it is desirable to place on record what is known of the plant and its capabilities. As to its identity, it was from the first conjectured that the seeds belonged to a plant very near the common purple-flowered Cowhage or Cow-itch plant of the Tropics, *Mucuna pruriens*. The difficulty, in the absence of adequate specimens, in identifying it with this was the fact that in the Cow-itch plant the pods are densely covered with stinging hairs of a brownish color. A plant so formidably armed, it was thought, could not safely be recommended for general cultivation. The name first given, *Dolichos multiflorus* (*Dioclea boykinii*), was clearly wrong. In these circumstances we are glad to find from the Queensland Agricultural Journal, volume ii, pages 370–371 (with a plate), that the plant has flowered and fruited in that colony, and that Mr. F. M. Bailey, F. L. S., the colonial botanist, has identified it as *Mucuna pruriens*, var. *utilis*. In this variety of the Cow-itch plant the pods are apparently devoid of stinging hairs. It is probably *M. utilis* of Wallich, described in Flora of British India (vol. ii, p. 187) as "cultivated variety" with velvety not hairy pods. This is figured in Wight's Icones (vol. i, t. 280). According to Watt's Dictionary of the Economic Products of India, "the young, tender pods are cooked and eaten as a vegetable." What may also prove to be the same plant, with jet black seeds, is cultivated as a rotation crop on sugar estates in Mauritius under the name of "Pois Mascate." The accounts given by interested parties in America respecting the agricultural value of the Florida velvet bean must be received with caution.—*Kew Garden Bulletin of Miscellaneous Information No. 140, August, 1898, p. 207.*

THE FLORIDA VELVET BEAN.—As I am receiving so many letters of inquiry from your readers about the Florida velvet bean, and being unable to answer each one separately, I would like to reply through the columns of your valuable and widely read paper.

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[a] There is a plate showing the velvet bean.

[b] From American seed.

I have been asked so many times by people all over the country to give them the origin of this marvelous and most wonderful forage and fertilizing plant, and from what country it came. I will answer by saying that its presence here in Florida can be traced back twenty-five years or more, and it has until recently been known among the common people as the "Climber." From weight of evidence I unhesitatingly give Florida the credit of being its original home.

During the past year the writer introduced this little wonder in almost every civilized country on the globe, and a crop from the seed sent has been grown the present season; but from reports received it still remains a stranger to all. No one so far as heard from claims to know anything about it. The celebrated Kew Gardens, London, grew it the present season as a curiosity. Its vigorous growth and wealth of foliage and vine attracted wide and universal attention. Every State in the American Union is also putting it to the test. From a flood of letters received I learn that, from late planting and early frosts, the seed is not maturing in all sections of our country. But as a successful feed, forage, and fertilizer crop, it has nothing but praise from every quarter, and condemnation from none. Our Government at Washington, recognizing its great value to our country at large, bought a carload of seed of the writer last July for distribution to the several States of our Union.—*Capt. E. A. Wilson, Florida (no town mentioned), in Agricultural Epitomist (Indianapolis, Ind.), February, 1899, p. 4.*

From the year 1898, wherever the velvet bean is mentioned, it is spoken of as *Mucuna utilis*, and publications devoted entirely to it began to be published, notably the following:

Alabama Agricultural Experiment Station Bulletin No. 104, "The Velvet Bean," by J. F. Duggar. April, 1899.

United States Department of Agriculture, Division of Agrostology, Circular No. 14, "The Velvet Bean," by Jared G. Smith. May, 1899.

Florida Agricultural Experiment Station Bulletin No. 60, "Velvet Bean," by H. K. Miller. January, 1902.

Bailey's Cyclopedia of American Agriculture, volume 2, pages 656–658, "Velvet Bean," by H. H. Hume. 1907.

THE IDENTITY OF THE FLORIDA VELVET BEAN.

The original description of *Mucuna utilis* by Wallich[a] is as follows:

The principal difference of this species, if indeed a species, and *M. prurita* consists in the hairs of its legumes being appressed and almost silky, not erect, rigid, and stinging. In all other respects they sufficiently agree. The flowers in both are purple. The greater size of this is probably attributable to cultivation, in which state only it is known.

This brief description is accompanied by an excellent plate of the plant, natural size, which is herewith reproduced, reduced one-half. (See Pl. I.) The identity of this plant of Wallich's is decidedly obscure. It is extremely difficult to see how it can be a mere variety of *Mucuna prurita*, as has been held by some authors, and it certainly has

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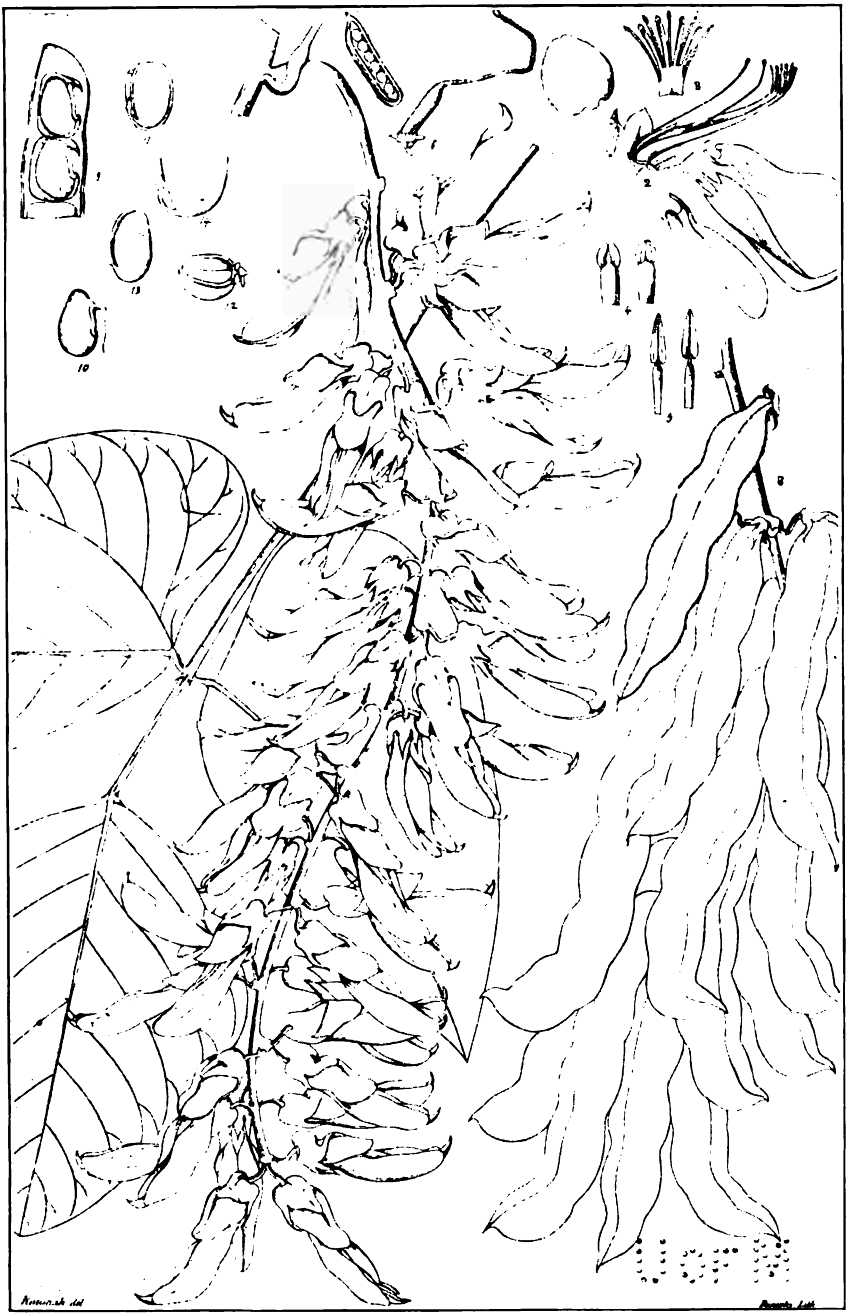
[a] Wight. Icones, t. 280. 1842.



WALLICH'S PLATE OF MUCUNA UTILIS, REDUCED SLIGHTLY MORE THAN ONE-HALF.

The description accompanying the original plate is as follows: "(1) Raceme, natural size; (2) a dissected flower; (3) stamens, showing the alternate long and round anthers; (4) round anthers; (5) long ones; (6) ovary; (7) the same opened; (8) cluster of pods; (9) portion of a legume opened; (10) a seed; (11) the same cut longitudinally; (12) transversely; (13) the cotyledons, testa removed; (14) embryo."

nothing to do with the West Indian *Mucuna pruriens*. As Hooker[a] long ago pointed out, the striking differences between the West Indian and the East Indian species are that the former has acuminate leaflets, whereas in *Mucuna prurita* they are obtuse or obtusish; *Mucuna pruriens* has a loose raceme, while *Mucuna prurita* has a dense raceme; *Mucuna pruriens* has the calyx lobes triangular and narrowly acuminate, whereas in *Mucuna prurita* they are rather broadly triangular and merely acute; *Mucuna pruriens* has a few inconspicuous stinging hairs on the calyx, whereas in *Mucuna prurita* they are much more numerous and are conspicuous on account of their rusty color. The seeds of the two species are also distinct. Those of *Mucuna pruriens* have a dark, brownish gray ground color with longitudinal markings of black. In all samples of *Mucuna prurita* examined the seeds are nearly black and unicolored. It may likewise be pointed out that the seeds of *Mucuna pruriens* are larger and not flattened on the sides, with the hilum only about one-half the length of the seed, while in *Mucuna prurita* the sides of the seeds are distinctly flattened and the hilum fully two-thirds as long as the seed.

In this connection the remarks of Voigt[b] are of interest. Under *Mucuna utilis* he says: "Certainly different from *M. prurita*, which has been cultivated in the garden here for many years, without its pods becoming less stinging." Voigt further identifies *M. utilis* with the black bean of Mauritius and Bourbon. This last-mentioned plant has been grown during the past season at Biloxi, Miss. Specimens of it agree exactly with the plate of *M. utilis*. It is also exceedingly probable that *Mucuna capitata* (Roxburgh) Wight and Arnott is the same thing, as the description agrees perfectly.

It is impossible to consider the Florida velvet bean the same as *Mucuna utilis*, from which it has several marked distinctions. The principal points of difference are as follows: *The size of the pod*, that of *Mucuna utilis* being 4 to 4½ inches long and ¾ inch wide and the Florida velvet bean usually under 3 inches long and not so wide; *the shape of the pod*, that of the Florida velvet bean being more cylindrical and blunt at the ends, less pronouncedly falcate, and not so decidedly ridged longitudinally; *the pubescence on the pod*, that of *Mucuna utilis* being thin, "appressed, and almost silky" hairy, while that on the Florida velvet bean is very dense, velvety, very soft, and weak; *the shape and size of the seed*, that of *Mucuna utilis* being large, long-oval, and flattened, whereas that of the Florida velvet bean is almost spherical and of smaller size; *the color of the seed*, which in the description of *Mucuna utilis* is not given, but from the figure the seed is not mottled or speckled, whereas the Florida velvet bean is. A comparison of figure 1 and Plates I, II, and III will illustrate the difference between the two plants.

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[a] Hooker. Bot. Misc., vol. 2, p. 348. 1831.

[b] Hortus Suburbanus Calcuttensis, p. 235.

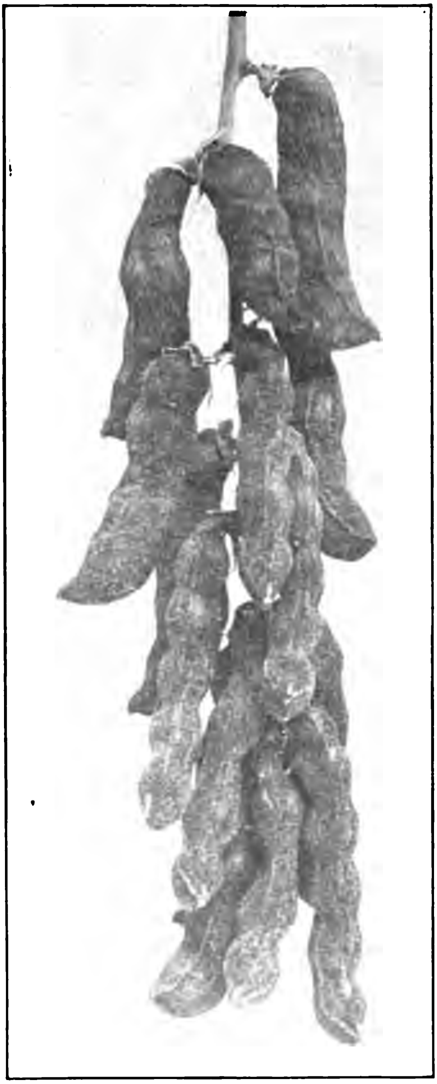
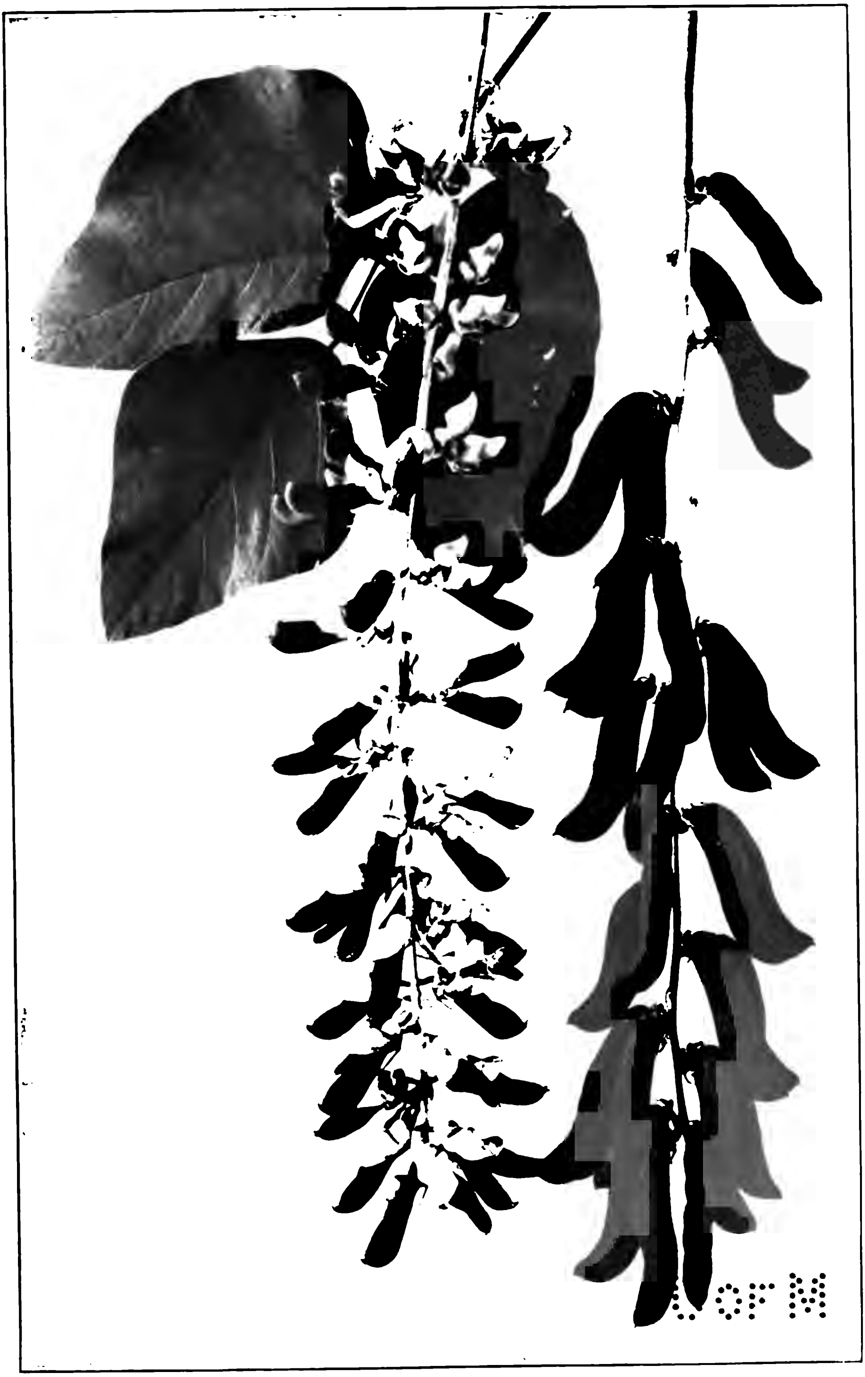


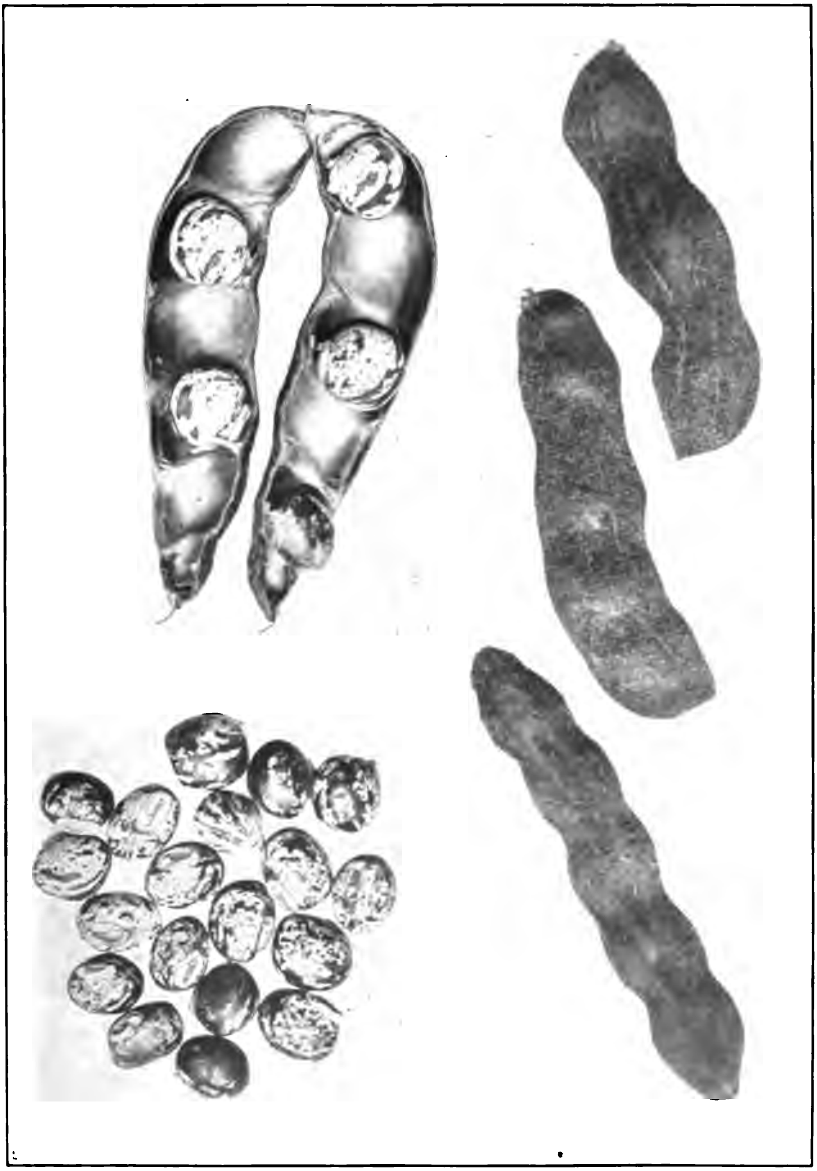
FIG. 1.—A cluster of mature pods of the Florida velvet bean. Two-thirds natural size.

The other described species belonging to the same group as the Florida velvet bean are *Mucuna cochinchinensis* Lour., which has white flowers and thick legumes, color of seeds not given; *Mucuna capitata* (Roxburgh) Wight and Arnott, with purple flowers and black shining seeds; *Mucuna nivea* (Roxburgh) Wight and Arnott, with white flowers and ash-colored seeds; *Mucuna lyoni* Merrill, with white flowers and ash-colored seeds, but quite distinct from *Mucuna nivea*; *Mucuna velutina* Hassk., with purple flowers and six different varieties as regards seeds, none of which are at all like the Florida velvet bean; *Mucuna bracteata* Baker, with gray leaves, broad, ovate, persistent bracts, and pods covered with gray, velvety tomentum when young; *Mucuna macrocarpa* Wallich, with woody stems and very large, half-woody pods, which are 1 to 1½ feet long and 8 to 12 seeded; and *Mucuna hirsuta* Wight and Arnott, with very hairy branches and densely silky leaves, especially beneath, and pods covered with stinging hairs.

Most of the above species, and in addition three apparently undescribed species, were grown in 1908 at Biloxi, Miss. These species are all very much alike in habit, the most obvious differences being found in the calyx, in the character



LEAF, CLUSTER OF FLOWERS, AND CLUSTER OF IMMATURE PODS OF THE FLORIDA VELVET BEAN. ONE-THIRD NATURAL SIZE.



MATURE PODS AND SEEDS OF THE FLORIDA VELVET BEAN. NATURAL SIZE.

of the pubescence on the pods, and in the shape, color, and size of the seeds. The differences in the character of the pubescence of the pods are such as to make it practically certain that they are specific in value and not merely varietal.

In view of these facts the Florida velvet bean is herewith described as a new species.

Stizolobium[a] ***deeringianum*** n. sp.—An annual, herbaceous, climbing vine sometimes 20 meters in length when growing on supports, and even on the ground attaining a length of from 2 to 6 meters, bearing long, pendent racemes of purple flowers which produce dark, velvety pods 5 or 6 centimeters long. Stems rather slender, terete, sparsely pubescent, with white, appressed hairs, especially on the ridges. Petioles equaling or exceeding the leaflets, pubescent like the stem, and continued for 2 to 4 centimeters beyond the lateral leaflets; stipules subulate, pubescent, about 1 centimeter long; stipels similar but smaller; petiolules about 5 millimeters long, stout, very pubescent. Leaflets rhomboid-ovate, the lateral ones oblique, membranaceous, acuminate-cuspidate, 5 to 15 centimeters long, about half as broad, sparsely pubescent above, especially on the veins, more densely pubescent beneath, the white hairs closely appressed. Inflorescence a raceme or thyrsus 15 to 30 centimeters long, pendent, bearing 5 to 30 flowers, usually about 12; rachis like the stem, but more pubescent; flowers borne singly or in twos or threes on short lateral branchlets. Bracts lanceolate-subulate, very pubescent, early fugacious. Calyx pubescent within and without with short, white, appressed hairs, 2 lipped, the upper lip broadly triangular, the lower lip 3 cleft, the lobes triangular-subulate, the middle one longest; stinging hairs absent. Corolla dark purple, 3 to 4 centimeters long; standard less than half the length of the keel, darker than the rest of the flower; wings slightly shorter than the keel, rather broad, oblanceolate-oblong, obtuse; keel straight to near the tip, where it curves sharply upward, the tip firm and acute; anthers of two sorts alternately long and short, the latter on much broader filaments; ovary linear, pubescent; style filiform, pubescent nearly to the tip; stigma small. Pods when mature 5 to 6 centimeters long, turgid, densely covered with a soft, nearly black, velvety pubescence without stinging hairs; valves with 1 or 2 or sometimes 3 obscure longitudinal ridges. Seeds 3 to 5 in each pod, subglobose, marbled and speckled with brown or black, and sometimes both, on ash-gray ground color (though pure gray and, it is said, pure black occur rarely), 1 to 1.5 centimeters in diameter. Hilum white, oblong-crateriform, less than one-half the length of the seed.

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[a] The genus Mucuna, as recognized by Bentham & Hooker and Engler & Prantl, clearly consists of two distinct genera, as pointed out by David Prain (Journal of the Asiatic Society of Bengal, vol. 66, new series, p. 404, 1897).

The genus Mucuna is first published in Adanson (Fam., vol. 2, p. 325, 1763) and the type species is *Mucuna urens*. The genus Stizolobium was first published by Patrick Browne, in 1756, in his history of Jamaica, and the type species is *Stizolobium pruriens*. The two genera are easily distinguished by the seed. In Stizolobium the hilum is linear, elevated, and oblong-crateriform, extending from one-fifth to nearly one-fourth the circumference of the seed. In Mucuna as restricted to include such species as *Mucuna urens*, the hilum is much elongated and band-like, extending nearly all the way around the seed. Furthermore, Mucuna is hypogeous in germination, while Stizolobium is not.

This description is based mainly on specimens in the United States National Herbarium collected by S. C. Carleton, Argo, Fla., in 1890.

Common name, Florida velvet bean. The original source of the species is unknown. At present it is cultivated extensively in Florida and to a less degree elsewhere.

The name *deeringianum* is given to this plant in honor of William Deering, of Cocoanut Grove, Fla.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 141, PART IV.

B. T. GALLOWAY, *Chief of Bureau.*

THE IMPORTANCE OF BROAD BREEDING IN CORN.

BY

G. N. COLLINS, Assistant Botanist.

Issued June 4, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

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B. P. I.—468.

THE IMPORTANCE OF BROAD BREEDING IN CORN.

By G. N. COLLINS, *Assistant Botanist.*

INTRODUCTION.

A study of the primitive types of corn and the history of the more productive varieties affords many indications that the improvement of our varieties is being checked by the injurious effects of inbreeding and that a further advance can best be secured by more fully satisfying the natural requirement of cross-fertilization. The conspicuous increase in yield that results from the crossing of distinct varieties and the rapid deterioration that follows self-pollination strongly support this view. Unfortunately the more recent changes in the methods of breeders have not been in the direction of better provision for cross-fertilization, but toward a still closer approach to self-pollination, the attempt being made to apply to corn theories and methods derived from plants naturally adapted for self-fertilization.

Until recently, the study of evolution and heredity has had little effect on the methods employed by breeders of domesticated plants and animals. Improved varieties were developed before Darwin's time in much the same way that they have been since. Whether the doctrines of Darwin or those of Lamarck, Naegeli, Weismann, or Cope should be accepted as giving correct interpretations has seemed to be a purely academic question from the standpoint of the practical breeder.

It is entirely different with the recently elaborated theory of De Vries. Converts to this new hypothesis have not been slow to claim that it has an important practical bearing, especially when taken in connection with the facts of Mendelism. Serious changes in the methods of breeding are being urged that are likely to have very injurious effects if they are generally applied to our varieties of Indian corn.

The definite mechanical character of these theories and the facility with which they appear to explain some of the facts of heredity render them very convincing. There is a tendency to forget their limitations and overlook the fact that whatever their value with close-fertilized plants like wheat they are entirely inapplicable to a cross-fertilized plant like corn.

The popularization of the new theories has continued until they are now not only urged as a basis for scientific experiments in breeding, but are even recommended as a guide for the practical farmer. It is assumed that uniformity is a normal condition. New "elementary species" are supposed to originate by sudden changes and then to remain uniform, so that no further change is possible after a "pure strain" has been isolated, until new mutations occur. If these theories were correct, then it would be true, as De Vries maintains, that the breeder is wasting time in attempting to ameliorate varieties by the continued selection of minute variations after the elementary species have been isolated.

The hundreds of improved forms of domesticated plants which have been derived and maintained by continuous selection through long periods of time sufficiently refute the claim that selection is ineffective and should warn breeders from the danger of abandoning too soon a system which has yielded such brilliant results. As applied to corn the De Vriesian doctrine is particularly dangerous, since it would replace the already close selection by a method of still narrower breeding, the nearest approach to self-fertilization that is possible with a cross-pollinated plant.

Independent of these theories, many corn breeders have been aiming at uniformity, and such will doubtless welcome this apparent justification. It is perhaps fortunate for the progress of corn breeding that the wide promulgation of these theories has been delayed until the fallacy of the system of close breeding is beginning to be appreciated and the more thoughtful and observant of our corn breeders are viewing with distrust the system of close selection and are casting about for an alternative method.

DEVELOPMENT OF THE PRESENT METHODS OF CORN BREEDING.

Stated broadly, the object of breeding field corn is to produce varieties that will give the largest yield of grain under given conditions. The latitude allowed by this simple object gives the corn breeder an advantage over the breeder of more specialized crops—an advantage which has not been fully appreciated. The varieties of sweet corn fall more nearly in the class with vegetables, and the many special requirements, such as taste, appearance, and uniformity make their improvement a much more complicated and very different problem from that of the improvement of field corn. With field corn the development of varieties with special qualities will not become an important consideration until the possibilities of corn as a human food are much more fully appreciated than at present.

In the early stages of corn breeding it was thought sufficient to select the largest and best-filled ears for seed. With the idea that like produces like, this was obviously the way to increase the size of the ear. It was soon found that some of the plants that produced large ears had undesirable characteristics and selection was moved from the crib to the field.

The next stage was reached when it was realized that, though the ear was large and well filled and the plant had no objectionable features, some of the plants failed to reproduce their desirable characteristics in subsequent generations. The finest plants are sometimes due to particularly favorable locations in the field rather than to inherent superiority. This led to the study of the behavior of the progeny of particular ears before deciding whether they were worthy of being used as the foundation of new varieties, and the so-called "ear to row" method of selection was developed. These more laborious methods of breeding have all operated to limit the number of individuals tested and to restrict the crossing.

The increased yields which follow an intelligent application of this method of selection when applied to an unimproved stock have caused two important factors to be largely overlooked: (1) The number of plants from which careful selection can be made by any one person is reduced from thousands to hundreds with a correspondingly reduced chance of securing the individuals really superior as breeders; (2) these methods restrict the free crossing that is normal to the species, unless accompanied by the extremely laborious method of hand-pollination, which still further reduces opportunity of selection and renders the method inadequate, except where experiments are conducted on a very large scale, beyond the reach of the average farmer.

It has long been known that self-pollinated ears yield plants of greatly reduced vigor, and that a few generations of self-pollination usually result in sterility. Yet in spite of this obvious danger sign, nearly all of our corn breeders have continued to produce varieties with the narrowest possible foundation, often by using a single ear as the basis of the new variety and taking measures to prevent the bringing in of any new strains for fear of contamination.

Had corn breeding developed independently the danger from narrow breeding would doubtless have been more fully appreciated, but modern corn-breeding methods have been largely adapted from methods that have proved successful with other crops, such as wheat, oats, and barley, in which self-pollination is the rule. With self-fertilized species it is as safe to start a variety from a single plant as it is to start a variety of apples from a single bud. Furthermore, these autogamous strains tend to show great varietal uniformity, and the degree of this uniformity is regarded as the measure of the purity of the strain. With corn, conditions are different. It is normally interbred and normally exhibits considerable diversity in conspicuous characteristics—diversities difficult to suppress even when the closest selection is practiced.

UNIFORMITY NOT ESSENTIAL IN CORN.

In the cultivation of many plants varietal uniformity is a prime requisite, and with plants where seed is not the part for which the crop is grown this uniformity may be secured by narrow inbreeding and narrow selection, without imminent danger of deterioration. With many plants a reduction in the quantity of seed or in its germinating power is of relatively small importance. Close breeding may be necessary and permissible in such crops as beets, cabbage, lettuce, or tobacco, where uniformity in vegetative characteristics is required. It may be profitable to produce uniform varieties of chickens, dogs, or ornamental plants, even though such varieties may be short lived. But the fancier's methods are not applicable to field crops. The corn grower receives a relatively small part of his profits in the form of prizes awarded on the score-card method of "point ratings," yet, except for the seedsman, this is the only monetary advantage in producing corn with perfectly uniform ears. That a corn planter should occasionally drop four or five grains instead of three in a hill is about the only reason that can be given for insisting upon uniformity in shape and size of kernels, and an occasional white speck in the yellow corn meal is advanced as sufficient warrant for the careful elimination from yellow varieties of all ears with white cobs. The desire for uniformity does not always have even these excuses. It is even urged by some breeders that the tassels and silk must be uniform in color, that the ears must be uniform in shape, with a fixed number of grains to the inch. There is not even a fancied pecuniary advantage in this, but it is held that diversity in even these unessential characteristics stamps a variety as mongrel and therefore undesirable.

Even the universal insistence upon large ears may not always be advisable, for it has resulted in the development of plants bearing single ears instead of the two or more ears that are normal to the species. Where the season is short the limitation to a single ear is a decided advantage, but under other conditions a plant producing two or three ears of moderate size may yield a quantity of shelled corn that sufficiently exceeds that on a single large ear to more than offset the additional cost of harvesting.

CONFUSION REGARDING THE TERM UNIFORMITY.

A misunderstanding regarding the meaning of the term uniformity has done much to spread the practice of inbreeding and has worked great injury to the cause of corn improvement. To the few successful breeders who have produced varieties of lasting value uniformity has not signified an identity of measurable characters, but is a kind of similarity of expression, so to speak, by which the breeder recognizes a family resemblance, much as we recognize the relatives of our intimate friends, although at a loss to indicate wherein the resemblance lies. Thus to an experienced breeder two ears of corn, with measurable characters that coincide as closely as possible, will immediately be recognized as belonging to different types. The ears and grains may be of the same size and shape, the color and indentation the same, yet to the practical breeder the two ears would appear to be lacking in uniformity. Conversely, ears which are obviously dissimilar in these particulars will promptly be recognized as belonging to the same strain.

The score card was an attempt to reduce this intimate and almost intuitive knowledge of the practical breeder to an exact science for wider application, but it has proved a lamentable failure—lamentable because it gave rise to the idea that the uniformity of score-card ratings was the kind of uniformity which successful breeders considered essential to valuable strains of corn, and because uniformity in score-card ratings can only be secured by rigid inbreeding.

CULTURAL TENDENCIES TOWARD INBREEDING.

The cultivation of corn is of very great antiquity in America, and the cultural operations to which it has been subjected from the earliest periods have differed radically from those applied to other crops. With primitive people the seed of other cereals is unavoidably mixed in planting, but corn is usually stored on the cob and the ears used for seed are carried into the fields at the time of planting, and the kernels shelled off as they are to be dropped into the ground. Thus the plants from the same parent ear grow up together, and with most primitive tribes, though the plantings may be considerable in the aggregate, the individual fields are in most cases so small that one or two ears will often suffice for the entire field. The opportunity for crossing is thus very slight. It would be natural for even the most primitive man to select for seed the largest ears or those that particularly caught his fancy, and the same type would be selected year after year. The seed ears also figure in many religious ceremonies, which no doubt tends to the establishment of definite standards of selection.

It is universally believed by the Indians of Central America that the varieties of corn in each locality are best adapted to that locality, and that other varieties brought in from other regions never yield so well. That this belief is well founded has been demonstrated by the numerous experiments of European settlers in tropical America, who are prone to regard as superstition this native belief and to import improved varieties from more or less distant localities. The failure is usually so complete the first year that the experiment is abandoned. This abnormal behavior of corn under new conditions intensifies the close breeding, and the close breeding in turn operates against the interchange of varieties by making the adjustments to the particular environment more delicate. That these primitive systems of breeding have not been indiscriminate is shown by the great number of well-defined types that exist among the American aborigines.

Among a number of primitive tribes where the cultivation of corn has reached a high state of development, the injurious effect of this close breeding appears to have been recognized, since they have methods of guarding against it. Thus the Indians in the region of Quezaltenango, in western Guatemala, and the Hopi Indians of Arizona make a regular practice of placing seeds of more than one local variety in each hill, with the idea that larger yields can be obtained in this way.

The very general fact that the immediate effect of crossing two closely bred strains is to increase the vigor is well exemplified in corn. Although this increased vigor of first-generation hybrids is well recognized by many practical corn breeders, the value of the fact has been largely obscured by the idea that the hybrid must be considered as a new variety and that uniformity must be secured before the results could have general application. To attempt to establish uniformity by a new course of selective inbreeding is to sacrifice the vigor gained by crossing.

Attention has been so persistently centered on the production of new and uniform strains that the yield and vigor of the first generation of hybrid plants as compared with the parents is seldom reported. In all the cases that have come to our attention the yield of the hybrid has been in excess of the average of the parents. Five cases reported by Morrow and Gardner,[a] of the Illinois Agricultural Experiment Station, gave increases over the average of the parents running from 1.9 per cent to 28 per cent, with an average increase of 14 per cent. McClure,[b] of the same station, also reports on 12 different hybrids of sweet, pop, soft, and flint varieties; 10 showed an increase in the weight of the ear in the first generation over the average of the parents, and one of the exceptions is explained by the author as being due to unfavorable situation, the decrease in the other case being 4.6 per cent, while the average increase for the whole series of 12 crosses is 16 per cent, running as high as 52.8 per cent.

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[a] Morrow, G. E., and Gardner, F. D. Bulletin 25, Illinois Agricultural Experiment Station, p. 179. 1893.

[b] McClure, G. W. Bulletin 21, Illinois Agricultural Experiment Station, p. 82. 92.

If similar increases had been secured by any change in cultural methods, experiments to determine the range of applicability of the new method would have been promptly inaugurated and the true value of the facts ascertained. Although the fact has long been established that significant increases can be secured by crossing, we are still without knowledge regarding the conditions necessary for this increase. It is to be expected that the increase will be greatest between strains that have been closely selected, but there is no direct evidence on this point. We should also lose no time in securing information regarding the amount of difference that should exist between the strains crossed to secure the maximum increase of vigor. There is a wide and almost untouched field in this direction that will require an enormous amount of experiment and observation before justice will have been accorded to this possibility.

The definite and well-known facts that self-fertilization of corn inevitably leads to sterility and that the yield can be increased by the crossing of varieties have not been sufficient to attract attention to the dangers of inbreeding and close selection. No middle course between the indiscriminate planting of the general run of seed and the rigid selection of a definite type seems to have been seriously considered. Had it been realized that diversity is as necessary to the life of the species as is chlorophyll to the life of the individual plant, it would have been evident that one might as well breed to eliminate the green color from the leaves as to suppress this normal variation. From a consideration of the habits of the plant the course suggested in undertaking the improvement of corn would be to seek the best methods for continuing to combine distinct strains, thus utilizing the increased vigor and productiveness resulting from their interbreeding.

While the crossing of our more or less inbred varieties may confidently be expected to result in increased vigor and fertility, it is hardly to be expected that the full amount of the increase in yield that follows such crossing can be maintained in future generations. The probability is that a part of the increased fertility of the hybrids will prove to be confined to the conjugate generation; that is, to the generation immediately following the crossing. In this generation male and female elements, representing the two parent varieties, are present in the nuclei of the plant, but have not completed the process of conjugation, with the result that a sort of protoplasmic tension exists, in some way associated with increased vegetative and reproductive activity.[a] There is good reason to believe that this is the case in certain cotton hybrids, and if it should also prove to be an important factor in the increased yields of corn hybrids the results would warrant the production of hybrid seed in a breeding plot each year for field planting the following year. To secure hybrid seed it would only be necessary to plant two distinct varieties in alternate rows, detasseling one variety and using the seed from the detasseled variety for the next year's general planting. Seed from the variety that was not detasseled would not be mixed and selections could be made to supply the breeding plot for the two following years. By detasseling the other variety in the next year a stock of pure seed of this also could be grown. By this system of alternation pure stocks of seed of the two varieties could be maintained. There would be produced every year a stock of hybrid seed for the field planting of the next year and a stock of pure seed of one of the varieties for planting the seed plots of the two following years.

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[a] Cook, O. F., and Swingle, W. T. Evolution of Cellular Structures. Bulletin 81, Bureau of Plant Industry, U. S. Department of Agriculture. 1905.

The same result could be approximated by planting in the same way and detasseling one of the varieties in one half of the field and the other variety in the other half of the field. By this method seed of both the varieties would be secured each year, but there would be considerable indiscriminate crossing.

The fact that corn is wind-pollinated makes the continual production of conjugate or first-generation hybrids on a commercial scale immensely more practicable with corn than with any other field crop.

In still another way the artificial crossing of two varieties may be expected to increase the yield. With such hybrids none of the seed is self-pollinated, while with the crop grown in the usual way the percentage of self-fertilized grain must be very considerable. In most of our varieties the natural proterandrous tendency of corn has been reduced, until under ordinary climatic conditions the pollen of nearly every plant is still being shed when the silks become receptive. Unless the wind is blowing when the pollen is shed a large amount of self-pollination is inevitable. It is to be expected, therefore, that any method of treatment that would eliminate or reduce this self-pollination would result in an increase of the vigor and yield of the resulting corn plants, even without hybridization. The use of detasseled plants for the production of seed may thus be found worth while, quite apart from the question whether detasseled plants themselves yield more than those that are not detasseled.

Whatever may be the true explanation of the increased fertility of hybrid corn plants, the fact remains that larger yields of corn can be secured in this way. The study of the methods by which these important factors can be made most effective should at least receive a place by the side of the study of elementary species and the quest ' uniformity.

THE ELIMINATION OF "BARREN STALKS."

Another factor which has worked toward the inbreeding and consequent deterioration of highly bred varieties of corn is the removal of the so-called "barren stalks." The elimination of nonproductive plants is undoubtedly desirable, but the removal of barren stalks as usually practiced is not a step in this direction. A truly barren stalk is one that fails to produce seed. So far as the seed is concerned, therefore, this elimination is automatic and inevitable, but it has been urged that the barren stalks must be removed before they produce pollen, on the theory that pollen from barren stalks is likely to cause deterioration in the progeny of neighboring plants. Where this practice is followed it results only in the detasseling of all proterandrous plants, for, as pointed out by Soule and Vanatter,[a] it is impossible to distinguish the truly barren plants at the time of tasseling. With many varieties, especially those which have not been subjected to rigid selection, some of the plants which eventually prove to be the most prolific show only small rudiments of ears at the time of tasseling. The continued removal of such plants results not in the elimination of barren stalks, but in the elimination of the plants which possess a valuable adaptation to avoid self-pollination. This weeding out of the more proterandrous individuals has been continued with some varieties until the majority of the plants produce staminate and pistillate flowers at the same time. When these varieties flower in comparatively still weather, there must be a large proportion of self-pollinated seed and a consequent weakening of the variety. This persistent tendency to proterandry can be thought of as a natural reaction of the species against the danger of extinction from inbreeding. Even the true barren stalks might represent a tendency on the part of the plant to become diœcious. In localities with very short seasons it may be well to discriminate against the tendency in the plant to put out ears too long after the tassel has matured, but elsewhere the avoidance of self-pollination is more important.

CONTINUOUS IMPROVEMENT THROUGH SELECTION.

The fact that narrow breeding in corn results in a reduction of vigor has remained unappreciated largely because narrow breeding is always accompanied by selection for yield and vigor. The two processes are opposed, so that movement in either direction is masked and counteracted. Varieties thus produced are delicately adapted to the exact conditions under which they have been selected, and often show marked deterioration when placed under new conditions. The very delicacy of the adjustment helps to insure the much desired uniformity, for with any change of characters the debility of the stock becomes more manifest and the elimination of the variant individuals is certain. Increased yields are obtained by making the yield of the individual plants more uniform, even when the full possibilities of production are not approached. The best plants of a highly bred variety are not conspicuously more prolific than the best individuals in fields from unselected seed.[a]

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[a] Bulletin 165, Virginia Agricultural Experiment Station.

This failure of varieties to continue to improve in vigor and fertility under continuous selection gives apparent support to the idea of De Vries that the initial selection of "pure strains" is the only progress that can be expected. It has already been seen that attempts to secure increased vigor by close selection are impeded by the weakening effects of inbreeding. When selection is not hampered in this way, but is directed to characters not dependent on vigor and fertility, and consequently not affected by inbreeding, continuous progress may be made. Thus in the selections made by Hopkins for high and low protein content, rapid and continuous progress was made and an extreme was reached far in excess of anything observed in the original sample. The last reports show that the plants were no more uniform with respect to these characters than at the beginning of the experiment.[b]

Though necessarily impeded by inbreeding, important advances in yield have been made by means of close selection, but the value of these improvements should not be allowed to obscure the fact that the full possibilities of production are not reached until the increment of vigor obtained by crossing has been added. Even if the yields obtainable by crossing were not larger than those to be secured by persistent close selection, it is easier to permit crossing than it is to provide the very careful and skillful selection required to maintain high yields without crossing. To use crossing as a means of sustaining fertility, instead of relying upon selection alone, would also keep our stocks in more normal physiological condition, more resistant to disease, and less liable to injury by adverse conditions.

SUMMARY.

The development of the present methods of corn breeding has resulted in greatly limiting the number of individuals that serve as a foundation for improved strains. The danger of this course, as shown by the sterility of self-pollinated plants, has been unheeded, largely because theories and methods have been carried over to corn from other crops which are normally self-pollinated or where a high degree of uniformity is essential.

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[a] It has recently been pointed out by Mr. O. F. Cook that the apparent advantage of selection is greatest in degenerating stocks. See Bulletin 146, Bureau of Plant Industry, U. S. Department of Agriculture, "The Superiority of Line Breeding Over Narrow Breeding."

[b] Smith, L. H. Ten Generations of Corn Breeding. Bulletin 128, Illinois Agricultural Experiment Station. 1908.

Great uniformity is of little or no economic value in corn varieties, and since it can be acquired only through close breeding it is actually undesirable to the grower. The natural requirements of cross-pollination make the problem of corn improvement entirely different from that of most of our cultivated plants.

Selection for increased yield with the maximum instead of the minimum of cross-breeding seems never to have been tried as a scientific experiment. On the other hand, the farmers of our corn-growing regions have practiced a system of broad breeding by choosing many ears from widely scattered plants in large fields and mixing the shelled corn before planting. Much of the basic improvement of our corn varieties may be ascribed to this system of increasing and maintaining vigor and fertility.

An effort to reduce the intimate intuitive knowledge of the successful breeder to measurable characters has led to the development of the score card. Instead of accomplishing the desired result, the score card has operated to intensify the closeness of selection, since uniformity in formal characters can be secured only by close breeding.

Although the methods that obtain among the primitive tribes of corn-growing Indians indicate that corn has been subjected to narrow breeding from remote times, the more intensive form of narrow breeding has been practiced for little more than a decade, yet the debilitating effects of this method are becoming apparent.

That corn is benefited by additional crossing, even when grown by primitive methods, is indicated by the custom which some tribes have of regularly mixing distinct strains to increase the yield.

It is abundantly demonstrated that the crossing of distinct varieties gives increased yields.[a] With the idea that only uniform varieties could be of value the practical importance of this fact has been overlooked and the gain has been limited by subsequent inbreeding of the hybrids. Should the increased yield of hybrid plants prove to be greatest in the first generation or should the complete elimination of self-fertilization prove an important factor, it is quite practicable to maintain a continuous supply of hybrid or cross-pollinated seed.

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[a] After this report was submitted in January, 1909, an article appeared by Dr. E. M. East, of the Connecticut Agricultural Experiment Station (see American Naturalist for March, 1909), describing additional instances of increased yields of corn hybrids. Thirty different crosses between varieties were grown in comparison with the parent varieties, with the result that "In every case an increase in vigor over the parents was shown by the crosses." In the four cases in which the yields were measured the product of the hybrid exceeded that of either parent, the increase of the hybrids over the parents averaging 77 per cent. Doctor East also considers the practicability of producing hybrid seed for commercial plantings and outlines a method practically identical with that suggested here.

A study of the habits of the plant from the standpoint of cross-fertilization makes apparent the nature of the so-called "barren stalks," which may be thought of as an adaptation to avoid self-pollination. The elimination of these proterandrous plants results in increasing the percentage of self-pollinated plants and is a practice of doubtful value.

The ill effects of inbreeding and selection for increased yield and vigor have tended to neutralize each other, and the consequent lack of continued improvement has lent color to the idea that continuous selection is ineffective. With characters that are not affected by decreased vigor continuous advance has been made by selection.

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BUREAU OF PLANT INDUSTRY—BULLETIN NO. 141, PART V.

B. T. GALLOWAY, *Chief of Bureau.*

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THE PRESENT STATUS OF THE CHESTNUT BARK DISEASE.

BY

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AND

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ISSUED AUGUST 30, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

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THE PRESENT STATUS OF THE CHESTNUT BARK DISEASE.

By HAVEN METCALF, *Pathologist in Charge*, and J. FRANKLIN COLLINS, *Special Agent, Investigations in Forest Pathology.*

HISTORY OF THE CHESTNUT BARK DISEASE.

In 1904 Mr. H. W. Merkel, of the New York Zoological Park, observed a disease which was destroying large numbers of chestnut trees in the city of New York. This disease is what is now known as the chestnut bark disease. Even at that time it is certain that it had spread over Nassau County and Greater New York, and had found lodgment in the adjacent counties of Connecticut and New Jersey. No earlier observation than this is recorded, but it is evident that the disease, which would of necessity have made slow advance at first, must have been in this general locality for a number of years in order to have gained such a foothold by 1904. Conspicuous as it is, it is strange that the fungus causing this disease was not observed or collected by any mycologist until May, 1905, when specimens were received from New Jersey by Mrs. F. W. Patterson, the Mycologist of the Bureau of Plant Industry. In the same year Dr. W. A. Murrill began his studies of the disease, publishing the results in the summer of 1906. By August, 1907, specimens received by this Bureau showed that the disease had reached at least as far south as Trenton, N. J., and as far north as Poughkeepsie, N. Y., and was spread generally over Westchester and Nassau counties, N. Y., Bergen County, N. J., and Fairfield County, Conn.

PRESENT DISTRIBUTION.

The present distribution of the chestnut bark disease is shown on the accompanying map (fig. 2). By this it will be seen that infection is now complete in the general vicinity of the city of New York. Outside of this area the disease already occurs at scattering points in a number of States. In every case its occurrence has been definitely authenticated by specimens which have been examined microscopically. Reports have been received indicating that the disease is found at many other places, but not being substantiated by specimens these localities have not been shown on the accompanying map. It is only fair to state, however, that such reports have been received from points as remote as Cape Cod, Wellesley, and Pittsfield, Mass.; Rochester and Shelter Island, N. Y., and Akron, Ohio.

The bark disease is entirely different from a disease which during the past twenty years has caused the death of many chestnut trees on the Atlantic slope, particularly south of the Potomac River. The latter disease, which is now being studied by the Department of Agriculture, is associated with insects, is much slower in action than the bark disease, and produces a stag-headed condition of the tree. It can be quite confidently stated that the bark disease does not yet occur south of Virginia and at only a few points in that State.

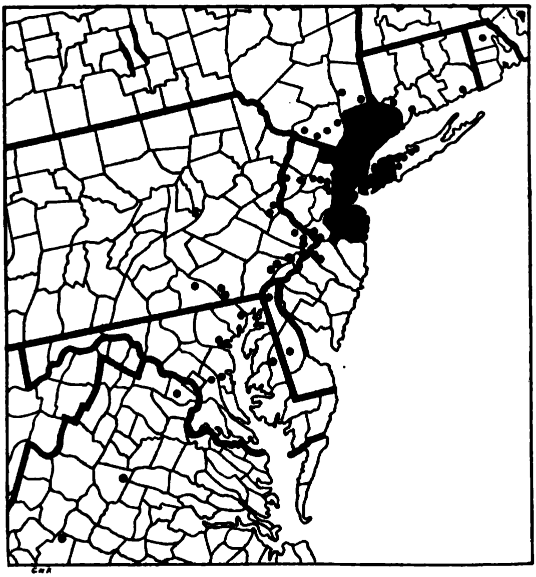

Fig. 2.—Map of the eastern portion of the United States, showing the distribution of the chestnut bark disease. The heavily shaded part shows the counties wherein infection is already complete. The round dots show other points where the disease is positively known to occur.

Investigations are in progress to determine the origin of the bark disease in America and the details regarding its spread. The theory advanced in a previous publication of this Bureau,[a] that the Japanese chestnuts were the original source of infection, has been strengthened by many facts. It yet lacks much of demonstration, however, and is still advanced only tentatively.

While the disease has spread principally from the vicinity of New York there is much to indicate that it occurred at other points at an early date. Chester's Cytospora on a Japanese chestnut, noted at Newark, Del., in 1902, may have been the bark disease. Observations by the junior writer indicate that this disease may have been present in an orchard in Bedford County, Va., as early as 1903, and that in Lancaster County, Pa., it probably was present as early as 1905. All other points shown on the map outside of the area of general infection appear to have been infected only within one or two years.

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[a] Bureau of Plant Industry, U. S. Department of Agriculture, Bulletin 121, Part VI. 1908.

The bark disease appears practically to exterminate the trees in any locality which it infests. A survey of Forest Park, Brooklyn, showed "that 16,695 chestnut trees were killed in the 350 acres of woodland in this park alone. Of this number about 9,000 were between 8 and 12 inches in diameter, and the remaining 7,000 or more were of larger size."

In a recent publication Dr. W. A. Murrill estimates the financial loss from this disease "in and about New York City" at "between five and ten million dollars." The aggregate loss throughout the whole area of country affected must be much greater.

The bark disease occurs on both chestnut and chinquapin, regardless of age, origin, or condition. It does not occur on any other tree so far as known. All reports of its occurrence on the chestnut oak (*Quercus prinus*) have proved to be unfounded. It is not yet known whether the goldenleaf chinquapin of the Pacific coast (*Castanopsis chrysophylla*) is subject to this disease.

According to Sudworth, the range of the native chestnut is "from southern Maine to northwestern Vermont (Winooski River), southern Ontario, and southern shores of Lake Ontario to southeastern Michigan; southward to Delaware and southeastern Indiana, and on the Allegheny Mountains to central Kentucky and Tennessee, central Alabama, and Mississippi." The range of the chinquapin is "from southern Pennsylvania (Adams, York, Franklin, and Cumberland counties) to northern Florida and eastern Texas (Neches River)." The bark disease may, therefore, be expected to occur at any point within these limits, as well as in any other localities where the chestnut is grown as an ornamental or orchard tree.

CAUSE AND SYMPTOMS.

The disease is caused by the fungus *Diaporthe parasitica* Murrill (also known as *Valsonectria parasitica* (Murrill) Rehm). The spores of this fungus, brought by some means from a previously diseased tree, enter the bark through wounds; possibly also in other ways. The leaves and green twigs are not directly affected. From the point of infection the fungus grows in all directions through the inner bark until the growth meets on the opposite side of the trunk or limb, which in this way is girdled. The wood is but little affected. Limbs with smooth bark attacked by the fungus soon show dead, discolored, sunken patches of bark covered more or less thickly with the yellow, orange, or reddish-brown pustules of the fruiting fungus.

In damp weather or in damp situations the spores are extruded in the form of long irregular " horns," or strings, at first greenish to bright yellow in color, becoming darker with age. Plate IV, figure 3, shows a part of a branch of a diseased chestnut tree magnified 3½ diameters. In this illustration the typical appearance of the pustules in damp weather and the projection of the spores of the fungus in the form of " horns," or threads, are shown. These threads may be especially conspicuous near the edges of diseased areas. If the spot is on the trunk or a large limb with very thick bark there is no obvious change in the appearance of the bark itself, but the pustules of the fungus show in the cracks of the bark and, on account of the destruction of the layers beneath, the bark often sounds hollow when tapped. A patch usually grows fast enough to girdle the branch or trunk that it is on during the first summer.

The damage may not be immediately apparent, since the water supply from the roots continues to pass up through the comparatively uninjured wood to the leaves, but when in the following spring the new leaves are put out they are usually stunted and soon wither. The appearance of such trees is very characteristic. Plate IV, figure 1, shows large chestnut trees killed by the bark disease. In this illustration the trees to the left show the characteristic stunted foliage, which indicates that they were girdled during the previous year, while the tree on the right having no foliage was presumably girdled by the fungus at least two summers before the photograph reproduced was taken. Plate IV, figure 2, shows an orchard tree with recently girdled branches. Nothing else except an actual mechanical injury—breaking off of trunk or limb—produces such an effect as is shown in these illustrations. The imperfectly developed leaves often persist on the dead branches throughout the summer.

The great damage which the disease has done thus becomes most apparent in the last week of May or the first week in June, giving rise to the false but common idea that the fungus does its work at this time of the year, when in reality the harm is done during the previous summer. If the first attack is on the trunk, of course the entire tree dies. If, on the other hand, the small branches are first involved, the tree may live for several years.

It is very easy for a person not familiar with fungi to confuse this parasite with various other fungi which occur commonly on the dead wood of chestnuts and other trees, such as species belonging to the genera Calocera, Cytospora, and Cytosporina. The superficial resemblance is sometimes very strong, but a microscopical examination instantly reveals the true nature of the organism in question. On account of this common confusion no dependable diagnosis of the bark disease can be made in a new locality without a microscopical examination of specimens by an expert.

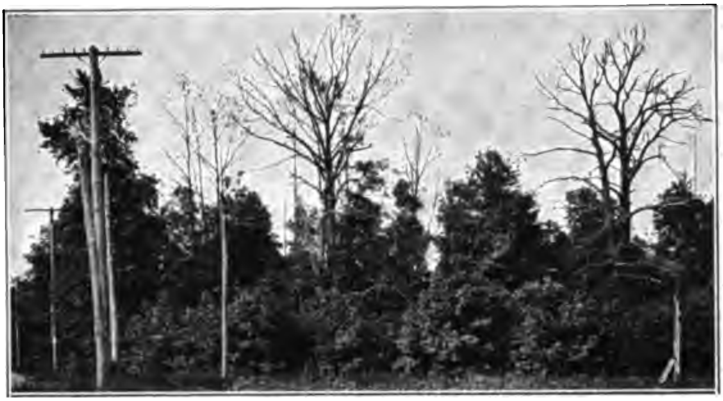

FIG. 1.—LARGE CHESTNUT TREES KILLED BY THE BARK DISEASE.

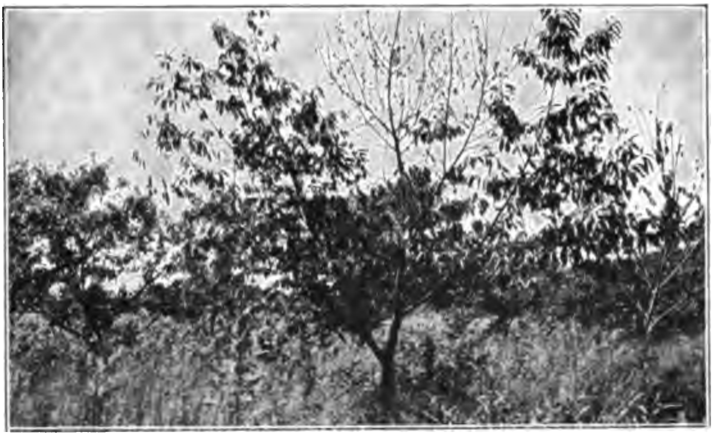

FIG. 2.—AN ORCHARD TREE, SHOWING RECENTLY GIRDLED BRANCHES.

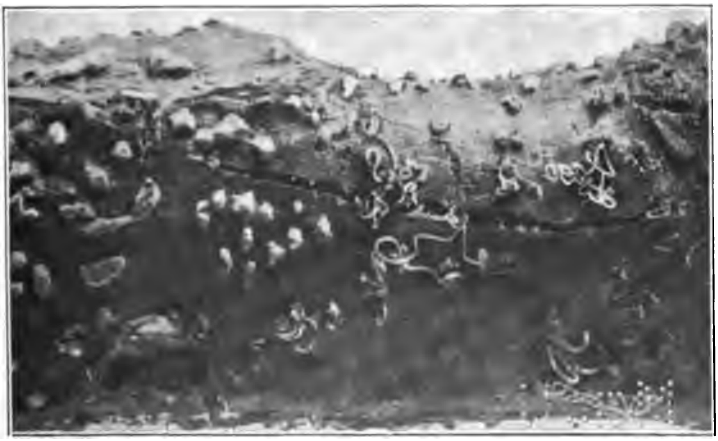

FIG. 3.—PART OF A DISEASED BRANCH OF A CHESTNUT TREE, SHOWING TYPICAL PUSTULES AND FORM OF SPORE DISCHARGE IN DAMP WEATHER.

(Magnified 3 diameters.)

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RESTRICTION OF SPREAD.

HOW THE FURTHER SPREAD OF THE BARK DISEASE MAY BE LIMITED.

BY THE INSPECTION OF DISEASED NURSERY STOCK.

It becomes more and more evident as this disease is studied that diseased nursery stock is the most important factor in its spread to distant points. In that part of the country where it is already well established in the native chestnuts its progress is rapid and sure, but there is no evidence at present that it is able to pass to remote districts, tens or hundreds of miles away, except on diseased nursery stock. Of course it is conceivable that the spores are carried by birds. Such distribution would, however, follow in general the great lines of bird migration north and south and hence would not be an important factor in the western spread, except locally. During the summer of 1908 nearly every chestnut nursery and orchard of importance in the Atlantic States north of North Carolina was visited, and very few were found free from the bark disease. Several cases were observed where the disease had obviously spread from the nursery to adjacent wild trees. This is the only way in which the disease is likely to spread beyond the Alleghenies.

It is therefore obvious that every State in which the chestnut or chinquapin grows should as speedily as possible pass a law putting the chestnut bark disease on the same footing as other pernicious diseases and insect pests, such as the San Jose scale, against which quarantine measures are taken. The Department of Agriculture will be glad to give detailed suggestions or advice regarding the framing of such laws. Inspectors who already have legal power to quarantine against this disease should now take special care that no shipment of chestnut stock escapes their rigid inspection.

A campaign of education should also be undertaken by pathologists and inspectors in every State in order to acquaint the public with the nature and appearance of the bark disease, so that it may be quickly recognized and stamped out in any particular locality in which it appears. The Department of Agriculture will cooperate in the following ways: Specimens from suspected trees sent in by any person will be promptly examined and the presence or absence of the disease reported. Typical specimens showing the disease (with the fungus previously killed by soaking in formalin to insure against any infection from this source) will be sent upon application to any inspector, forester, pathologist, or other State or experiment station officer, to any nurseryman or orchardist growing chestnuts, or to any botanist or teacher of botany. So far as the supply permits lantern slides and photographs will, upon application, be loaned for special lectures, exhibits, etc., to the officers of States, experiment stations, or colleges. By these means the inspectors first, and then the general public, may become familiar with the appearance and work of the disease in localities that it has not yet reached, and when it does appear may be able to recognize it before it is too late to take efficient measures against it.

Although its present distribution is that shown by the map (fig. 1), the bark disease may be confidently looked for in any orchard or nursery in the United States that contains chestnut trees. All such places should therefore be rigidly inspected at the earliest possible date.

BY THE PROMPT DESTRUCTION OF DISEASED TREES.

When the bark disease is first noticed in any locality, all the affected trees should be immediately cut down, unless, as in the case of orchard and some few ornamental trees, they are of sufficient individual value to warrant special treatment. Diseased trees if untreated are doomed to death in any case. If permitted to stand, every such tree becomes a center of infection, certain to spread the disease to all neighboring trees, and so long as it will soon die if left to itself the sooner it is cut down the better.

When cut, the brush should be immediately gathered and burned in order to destroy the fungus in the bark. Whenever the bark is removed from the trunk, as, for example, when the trees are to be used for poles, it should be immediately burned with the brush. Even when the tree is to be used for firewood an effort should be made to cut off at least all the diseased patches of bark on the trunk and large limbs when the tree is cut and to burn this bark along with the brush; otherwise the brush and the piled wood will continue to spread infection, since it has been found that the fungus continues alive on dead bark for at least six months after cutting.

Sprouts arising from the stumps of cut trees will be free from the disease for the first year at least, but must then be carefully inspected to be sure that no infection has persisted.

BY THE TREATMENT OF DISEASED TREES.

During the past two years the Office of Investigations in Forest Pathology has been conducting certain experiments and collecting information in regard to the best methods of treating diseased trees.

At present it is impossible definitely to record general beneficial results from any of the sprayings which have been undertaken or have been under observation. This may in part be due to the fact that it is yet too early to judge satisfactorily all the results and in part, perhaps, to the infrequency of sprayings.

Observations and experiments seem to bear out the statement that it is very improbable that any method of spraying can interfere with the growth of the fungus if it has once established itself in the inner bark, but it may be of considerable importance in preventing the development of spores which come from other trees or from other parts of the same tree.

It has already been demonstrated that the crotches of branches and enlarged bases of sprouts are very susceptible to infection because they are favorable places for the lodgment of water, dust, spores, etc. In a large majority of cases infections are definitely known to have originated at a point where the outer bark had been injured in some way, leaving the inner living bark exposed, or where the entire bark over a more or less limited area had been stripped from the tree or cracked and split away from the wood. Certain injuries which are known to have afforded entrance for the disease have been of such a nature that they might easily be overlooked, while others have been quite obvious, even to the careless observer. Among the latter may be mentioned broken limbs, split limbs, branches which have been carefully cut but not properly treated with tar or paint, bruises from hames, plows, and cultivators; also poor grafts and diseased grafting scions. Among the former may be included bruises from boot heels, climbing spurs, holes made by borers and other insects, knife and saw cuts, and frost cracks.

Almost the only treatment that can at present be safely recommended as surely retarding the spread of the disease to a greater or less extent is one which will never be of practical use except in the case of orchard trees or certain valuable ornamental trees. It consists essentially in cutting out the infected branches or areas of bark and carefully protecting the cut surfaces from outside infection by means of a coat of paint or tar. This cutting must be thoroughly done and the bark of every infected place entirely removed for a distance of at least an inch (where the size of the branch permits) beyond the characteristic, often fan-shaped, discolored areas produced by the growing fungus in the inner bark. All small infected twigs or branches should be cut from the tree, the cut being made well back of the diseased area. A pruning knife with an incurved tip, a hollow gouge, or any other clean-cutting instrument will serve for cutting out diseased spots. So far as the exigencies of the case will permit, all borers' holes should be cut out. It has been repeatedly observed in the field that infection often starts where borers are at work, or even at the old holes made by them. The paint or tar may be applied by means of a good-sized brush, care being taken to cover every part of the cutting. Treatment should begin, or observations at least, at the base of the tree and the fact ascertained whether the disease has already girdled the trunk. If such is the case it will be a waste of time to attempt any treatment; instead, cut the tree down at once. A rigid watch must be kept, especially during the growing season, for new infections or infections which were overlooked in the earlier examinations, and if any are observed they must be treated promptly, as above mentioned. Constant vigilance is necessary to keep the disease in check. It is suggested that examinations be made about June 1, July 15, and September 1. During a very rainy or foggy season, when conditions are particularly favorable for the growth of fungi, it may be advisable to inspect as often as once a month.

In regions in which the disease is so widespread that almost every tree is infected, as, for instance, within 25 miles of the city of New York, it is extremely doubtful whether any individual treatment will pay. Under such conditions immediate reinfection is almost sure to occur at one or more of the small unnoticed abrasions or injuries which are quite certain to exist on most trees. In a region, however, where only isolated cases have yet appeared it is quite possible to stamp out the disease, or at least to prevent its rapid spread, by promptly cutting out and carefully burning all diseased bark and limbs, thus destroying these new sources of infection. If a tree is too badly infected to be worth treating it should not be left standing, for it will then become a continual menace to all surrounding chestnuts.

The Office of Investigations in Forest Pathology asks the cooperation of all persons who have observed the disease or experimented with it in any way. If such people will send in an early report of the kind of treatment used, time of treatment, methods employed, and results obtained (even if adverse), it may be possible to arrive at an earlier and more definite conclusion in regard to the possibilities or impossibilities of control than would otherwise be the case.

CONCLUSIONS.

It is to be hoped that in the economy of nature some limiting factor will arise to check the spread of the bark disease before it has wrought the same destruction throughout the country that it already has in the vicinity of New York. But at present there is nothing in sight that promises even remotely to check its spread into new territory except the general adoption of the measures advocated in these pages. It can not be argued that because of its apparently recent origin and rapid spread it will soon disappear of itself. Such diseases as pear-blight and peach yellows have been in the country for more than a century and yet show no sign of abating except when actively combated by modern quarantine methods. Nor can any conclusions be drawn from the fact that chestnuts in the Southern

States have suffered from a disease during the past twenty years, since, as already stated, that is a totally different thing from the bark disease.

Where the bark disease is already firmly established and has attacked 50 per cent or more of the chestnut trees, as in the vicinity of the city of New York, it is probably too late to try to do anything, but where the disease is just appearing there is no reason to doubt that strict quarantine methods will apply as well to this as to any other disease, whether of plants or animals. The question to settle is simply which is more costly—to use the methods recommended or to lose the trees. The people concerned must decide.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 142.

B. T. GALLOWAY, *Chief of Bureau.*

SEEDS AND PLANTS IMPORTED

DURING THE PERIOD FROM APRIL 1 TO JUNE 30, 1908:

INVENTORY No. 15; Nos. 22511 TO 23322.

ISSUED FEBRUARY 25, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., October 19, 1908.

Sir: I have the honor to transmit herewith, and to recommend for publication as Bulletin No. 142 of the series of this Bureau, the accompanying manuscript, entitled "Seeds and Plants Imported During the Period from April 1 to June 30, 1908: Inventory No. 15; Nos. 22511 to 23322."

This manuscript has been submitted by the Agricultural Explorer in Charge of Foreign Seed and Plant Introduction with a view to publication.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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B. P. I.—418.

SEEDS AND PLANTS IMPORTED DURING THE PERIOD FROM APRIL 1 TO JUNE 30, 1908: INVENTORY NO. 15; NOS. 22511 TO 23322.

INTRODUCTORY STATEMENT.

This fifteenth inventory of seeds and plants imported by the Office of Foreign Seed and Plant Introduction between the dates of April 1 and June 30, 1908, inclusive, comprises 812 numbers, and among the more important are those which our agricultural explorer Mr. Frank N. Meyer secured personally in his exploration trips in northern and central China. While it is too soon to tell anything about the real value to the country of these new importations, it may be worth while to call especial attention to certain ones from which we expect more than others. Occasionally, it is the thing of which little is at first expected that turns out the most important, but as a rule the predictions of the explorer in the field have come true.

Among the plants from Mr. Meyer are some especially interesting shade and ornamental trees, which he secured at great personal discomfort and risk from the almost barren mountains of the Wutai, where the climatic conditions are similar to much of the territory of the Northwestern States. The unusual difficulties of collecting seeds in these mountains will be appreciated when it is mentioned that of some species only single trees are standing in absolutely barren wastes extending for scores of miles around. Although Mr. Meyer made two trips to this inhospitable region, it was quite impossible for him to be on hand when the seeds of single rare elms and spruces ripened and, as can well be believed, the wild rodents which were on the spot did not wait for him. Some of the things of which he obtained cuttings have been pronounced new by Professor Sargent, of the Arnold Arboretum, and it is to be regretted that more material from this region could not have been secured.

Of items of interest from other parts of China, Mr. Meyer forwarded four distinct varieties of the *Yang Mae*, or strawberry tree (*Myrica nagi*); the evergreen chestnut (*Castanopsis tibetana*); *Ulmus pumila*, a promising dry-land elm from Manchuria for the Northwest; the remarkable white-barked pine (*Pinus bungeana*), which can hardly fail to attract the attention of our landscape gardeners; four species of lilac as yet undetermined; five species of Chinese roses; a very unusual collection of twenty-nine forms of bamboos, some of which are hardy enough to grow in the climate of Peking, which resembles that of Philadelphia; a wild oat from the dry elevated portions of the Wutaishan, and soy beans, cowpeas, sorghums, cottons, and many other very valuable things from this great Klondike of new plant varieties, where almost every cultivator saves his own seeds and thus originates new strains.

Special mention should be made of an unusual piece of introduction work which Consul Magelssen, of Bagdad, carried out at our request, i. e., the securing and proper labeling of what may be considered one of the most successfully landed collections of Arabian date-palm suckers.

Through the increasingly large number of friends of plant introduction both abroad and at home a number of interesting things have been secured by correspondence: Cork acorns from southern Spain; a summer orange called the *Natsu mikan*, from Japan, which ripens in midsummer and is served on the tables of foreigners there just as the pomelo is in America; a collection of Indian green-manure and fodder plants from Nimboli; a broad-leaved variety of alfalfa from Elche, Spain; a collection of taros from Cochin China; a collection of rare sorghums from Entebbe, Uganda; the sugar palm from the East Indies; the white Alfonso mango from Bombay; a unique collection of wild and cultivated potatoes from the archipelago of Chiloé, in southern Chile, the home of the potato, and from the adjoining mainland, made by Mr. José D. Husbands; and a collection of Guatemalan cacti and a Central American dahlia secured for us by the late Prof. W. A. Kellerman just before his unfortunate death in the Guatemalan forest.

It should be repeated that the seeds and plants here listed are not necessarily for distribution, nor is it always possible to supply those who desire the various things listed here with what they want; but it is the aim of the office to get anything that a plant breeder or plant experimenter wants, whether it appears in these inventories or not, provided it is not already on the market, in which case the applicant will be referred to the catalogues which advertise it. To introduce a plant and get it into the regular trade channels without in any way interfering with the legitimate business in plant novelties which the seedsmen and nurserymen of the country are so well carrying on is one of the objects of our work.

The botanical determinations of the material are, as in the previous inventory, those of Messrs. W. F. Wight and H. C. Skeels, while the inventory has been prepared by Miss Mary A. Austin.

David Fairchild,
Agricultural Explorer in Charge.

Office of Foreign Seed and Plant Introduction,
Washington, D. C., October 7, 1908.

INVENTORY.

22511. Pueraria thunbergiana (S. & Z.) Benth. **Kudzu.**

From Yokohama, Japan. Purchased from L. Boehmer & Co. Received April 4, 1908.

See No. 22341 for description.

22512. Rollinia orthopetala A. DC.

From Pará, Brazil. Presented by Prof. C. F. Baker, Museu Goeldi, Caixa Postal No. 399, through Mr. O. W. Barrett. Received April 4, 1908.

"The finest anonaceous fruit of tropical America." (*Baker.*)

"Tree 30 to 40 feet high; leaves oblong, acuminate, acute at base; corolla 1 inch in diameter, greenish yellow. Fruit size of an infant's head, greenish yellow; flesh white, sweet. Grows in flooded woods along the Amazon." (*Martius.*)

22513 to 22523.

From Bridgetown, Barbados, British West Indies. Presented by Mr. John R. Bovell, superintendent, Agricultural Department, at the request of the Imperial Commissioner of Agriculture for the West Indies, through Mr. O. W. Barrett. Received April 4, 1908.

22513. *Milady.*
22514. *Banana tannia.*
22515. *Red tacca.*
22516. (Unknown.)
22517. *Choice Marquis.*
22518. *China eddo.*
22519. *Geremy Barbados.*
22520. *Leefman.*
22521. *Button tannia.*
22522. *Gray Jack.*
22523. *White Leftman.*

"A collection of taros and yautias which are grown extensively as wet-land crops in Barbados. Procured for the collection of these plants in Florida." (*Fairchild.*)

22524 to 22527. Juglans spp. **Walnut.**

From Baumschulenweg, near Berlin, Germany. Purchased from Mr. L. Späth. Received March 28, 1908.

Notes taken from Mr. L. Späth's catalogue for 1907–1908.

22524. × Juglans intermedia pyriformis Carr. (J. nigra × regia?)

A hybrid with large, multi-pinnate, light green leaves.

22525. × Juglans intermedia vilmoriniana Carr. (J. nigra × regia?)

A beautiful and imposing tree, perfectly hardy.

22524 to 22527—Continued.

22526. JUGLANS REGIA L.

J. regia fertilis Hort., *J. regia praeparturiens Hort.* Bush walnut; very early bearing.

22527. JUGLANS REGIA L.

J. regia rubra Hort. Red-skinned walnut.

22528. VITIS VINIFERA L. **Grape.**

From Niles, Cal. Presented by the California Nursery Company. Received at the Plant Introduction Garden, Chico, Cal., March, 1908.

Sultanina Rosea. A seedless variety. (See No. 3921 for description.)

22529. PANICUM MAXIMUM Jacq.

From Livingstone, Victoria Falls, northwestern Rhodesia. Presented by Mr. C. E. F. Allen, conservator. Received April 6, 1908.

"A valued grass in this country for hay and pasture." (*Allen.*)

22530. LANDOLPHIA CAPENSIS Oliv.

From Pretoria, Transvaal, South Africa. Presented by Prof. J. Burtt Davy, agrostologist and botanist, Transvaal Department of Agriculture. Received April 6, 1908.

"A small bush of the Magaliesberg. These fruits have an agreeable flavor and are used for jam and brandy and are eaten raw. The fruit is known as the 'wild peach' or 'wild apricot.'

"This Landolphia is not likely to yield commercial rubber. The bush requires a warm, almost frostless situation." (*Davy.*)

22531. ANONA CHERIMOLA Mill. **Cherimoyer.**

From Island of Madeira. Presented by Mr. Charles O. L. Power. Received April 6, 1908.

"These cuttings were taken from a tree which produces good-sized, normal fruit of the smooth-skinned variety; it has no particular name here.

"It is the best tree as regards size and quality I have in my garden, but, as is the case with all cherimoyers here, both the size and quality vary very much from year to year." (*Power.*)

22532. HORDEUM POLYSTICHUM TRIFURCATUM (Schlect.) Asch. & Graebn. **Barley.**

From Fort Collins, Colo. Secured from Prof. W. D. Olin, agronomist, Agricultural Experiment Station. Received April 8, 1908.

Hull-less. "Grown from No. 12709. Adapted to high altitude." (*Derr.*)

22533. CRATAEGUS PINNATIFIDA Bunge. **Hawthorn.**

From Shantung Province, China. Presented by Rev. J. M. W. Farnham, Chinese Tract Society, Shanghai, Kiangsu, China. Received March 26, 1908.

"The Chinese name for this fruit is *San dzo*, the first syllable of the word, San, means mountain and would point to its cultivation in mountainous regions. It is about the size of a crab apple and resembles the thorn apple, of which I presume it is a species. It makes an exceptionally nice jam. The fruit when ripe is washed and each one cut open to see that there is no decay or

22533—Continued.

worm, and the whole is boiled. It is then rubbed through a sieve to separate the skin, seeds, etc. The pulp is then *slightly* cooked with sufficient sugar. If much boiled it turns to jelly. The taste and flavor remind me of the New England boiled cider-apple sauce, in Pennsylvania called 'apple butter.' I think it has a nice aromatic flavor, and if not cultivated in America I have sent you seeds enough to give it a speedy introduction." (*Farnham.*)

22534 and 22535. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Weihsien, China. Presented by Mrs. C. W. Mateer. Received April 4, 1908.

22534. Yellow. "This bean is used for making lamp and cooking oil and for flour to make cakes; also for bean curd (a mush curdled by caustic soda and eaten fried). All these are nourishing, but more esteemed by Chinese than foreigners. The refuse after expressing the oil forms a cake (round) 2 feet in diameter and 3 inches thick. This is exported for feeding animals (pounded fine) and enriching land." (*Mateer.*)

22535. Black. Similar in appearance to *Cloud.*

22536 to 22540.

From Chefoo, Shantung, China. Presented by Mr. Hunter Corbett, through Rev. J. M. W. Farnham, of Shanghai, China. Received April 4, 1908.

The following seeds, varietal descriptions by Mr. H. T. Nielsen:

22536 to 22538. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

22536. Green. Similar to No. 17857.

22537. Green. Similar to No. 17262, *Yosho.*

"Chinese names (S. P. I. No. 22536) *Ching teo* and *Luh teo;* (S. P. I. No. 22537) *Whong teo.* These beans are used extensively for the manufacture of oil; the bean cake which remains after the oil has been pressed out is shipped south and extensively used as a fertilizer in vegetable gardens. Will grow well on level or high and hilly land. Is used by the people largely for food, being ground and made into a curd, also put in water and soaked until well sprouted and used as a vegetable. It is also boiled and eaten in the same manner as rice." (*Corbett.*)

22538. Black. Similar in appearance to *Cloud.*

"Chinese name *Shao hih teo.* Used chiefly for feeding animals." (*Corbett.*)

22539. VIGNA UNGUICULATA (L.) Walp. **Cowpea.**

Whippoorwill. Similar to Nos. 17330, 17849, and 21085.

"Chinese name *Hung chiang teo.* Planted in orchards and in ground overshadowed by trees, etc." (*Corbett.*)

22540. PISUM ARVENSE L. **Field pea.**

"Chinese name *Wan teo.* Used extensively in the manufacture of vermicelli." (*Corbett.*)

22541 to 22549.

From Chelsea, S. W., London, England. Presented by James Veitch & Son. Received April 3, 1908.

22541. ACONITUM HEMSLEYANUM E. Pritzel.

22541 to 22549—Continued.

22542. ACONITUM sp. (?)

22543. ASTILBE sp. (?)

22544. ARTEMISIA LACTIFLORA Wall.

22545. BERBERIS ACUMINATA Franch.

22546. JASMINUM PRIMULINUM Hemsl.

22547. VITIS ARMATA Diels & Gilg.
Var. *Veitchii*.

22548. LONICERA MAACKII (Rupr.) Herd.

22549. LONICERA TRAGOPHYLLA Hemsl.

22550 to 22555.

From Groningen, Netherlands. Presented by Mr. J. W. Moll, director, Botanic Garden. Received April 8, 1908.

22550. ARRHENATHERUM ELATIUS (L.) Beauv.

22551. PANICULARIA MAGELLANICA (Hook. f.) Kuntze.

22552. PODOPHYLLUM EMODI Wall.

22553. LATHYRUS MONTANUS Bernh.

22554. LATHYRUS NIGER (L.) Bernh.

22555. LATHYRUS VERNUS (L.) Bernh.

22556. GARCINIA TINCTORIA (DC.) W. F. Wight. (XANTHOCHYMUS TINCTORIUS DC.)

From Alas Besorki, Java. Presented by Mr. W. S. Lyon, Manila, P. I. Received April 7, 1908.

"A robust grower." (*Lyon.*)

"Introduced as a possible stock for the mangosteen." (*Fairchild.*)

22557. CYNARA SCOLYMUS L. **Artichoke.**

From Algiers, Algeria. Purchased from Dr. L. Trabut. Received April 6, 1908.

Violet Provence.

22558 and 22559. MEDICAGO SATIVA L. **Alfalfa.**

From Gunnison, Utah. Purchased from Mr. W. H. Gribble, through Mr. C. J. Brand. Received April 8, 1908.

22558. Irrigated.

"Grown at Centerfield, Utah, in the San Pitch Valley. This seed is grown from the first crop of the season." (*Brand.*)

22559. Dry land.

"Grown in the Sevier Valley, near Gunnison, Utah, in 1907." (*Brand.*)

22560 to 22563. JUGLANS REGIA L. **Persian walnut.**

From Troyes, France. Purchased from Baltet Fréres. Received April 9, 1908.

22560. *Chabert.*

22561. *Franquette.*

22562. *Mayette.*

22563. *Parisienne.*

22564 and 22565.

From Pretoria, Transvaal, South Africa. Presented by Prof. J. Burtt Davy, government agrostologist and botanist, through Mr. C. V. Piper. Received April 10, 1908.

22564. PENNISETUM AMERICANUM (L.) Schum. **Pearl millet.**

" *um-Vellivelli.*"

22565. ELEUSINE CORACANA (L.) Gaertn. **Ragi millet.**

" *Mpoho.*"

" Both of these have been grown in the low country and are from this season's crop just harvested." (*Davy.*)

22566 and 22567. CITRUS AURANTIUM L. Orange.

From Poona, Bombay, India. Presented by Mr. N. M. Bhagawat, acting superintendent, Empress Botanical Gardens. Received April 10, 1908.

22566. *Ladoo.* (See No. 8441 for description.)

22567. *Suntra.* (See No. 8446 for description.)

22568 and 22569. VICIA FABA L. Broad bean.

From Hangchow, Chehkiang, China. Presented by Dr. D. Duncan Main and Rev. J. H. Judson. Received March 26 and April 6, 1908.

22568. Small green.

22569. Brownish green. Medium size.

22571 to 22629.

From Peking, Chihli, China. Received through Mr. Frank N. Meyer, agricultural explorer, at the Plant Introduction Garden, Chico, Cal., February 4, 1908.

A collection of cuttings and seeds, as follows:

22571. DEUTZIA sp.

From Shutseshan, Chihli, China. "(No. 152, Nov. 18, 1907.) A low-growing Deutzia, found here and there in crevices of the rocks. May prove to be a valuable little shrub for gardens in semiarid regions." (*Meyer.*)

22572. FRAXINUS BUNGEANA DC.

From Pangshan, Chihli, China. "(No. 155, Nov. 20, 1907.) An ash growing in rocky situations and on steep mountain sides. Attains, apparently, no great size. May be of use as a foresting plant in semiarid regions." (*Meyer.*)

22573. (Undetermined.)

From Pangshan, Chihli, China. "(No. 156, Nov. 20, 1907.) A low, very bushy shrub, found growing between bowlders. Looks very much like *Syringa amurensis* Rupr. Will be valuable as a garden shrub in semiarid regions." (*Meyer.*)

22574. SPIRAEA sp.

From Pangshan, Chihli, China. "(No. 157, Nov. 20, 1907.) A Spiraea which may be of use as a garden shrub in semiarid regions, as it grows in crevices of rocks and in dry and sterile locations." (*Meyer.*)

22571 to 22629—Continued.

22575. Spiraea sp.

From Pangshan, Chihli, China. "(No. 158, Nov. 20, 1907.) A very low growing Spiraea, with adiantum-like leaves. May be of use as an ornamental shrub for rockeries or for gardens in semiarid regions." (*Meyer.*)

22576. Prunus sp. **Plum.**

From Pangshan, Chihli, China. "(No. 162, Nov. 21, 1907.) A double red-flowered, bushy plum called *Yu men tau.* Said to be very fine looking in springtime. Propagated by being budded on to *Amygdalus davidiana* or by layering." (*Meyer.*)

22577. Prunus sp. **Plum.**

From Pangshan, Chihli, China. "(No. 163, Nov. 21, 1907.) A large-flowered, bushy plum, the flowers of which are said to have a blue color. Chinese name *Tsu tsa lau hua.* Probably a variety of No. 162 (S. P. I. No. 22576)." (*Meyer.*)

22578. Catalpa bungei C. A. Meyer.

From Pangshan, Chihli, China. "(No. 164, Nov. 21, 1907.) Chinese name *Wu tung shu.* A fine flowering tree; also of use for wind-breaks and for poles. Adapted to semiarid regions." (*Meyer.*)

22579. (Undetermined.) **Bamboo.**

From Pangshan, Chihli, China. "(No. 165, Nov. 21, 1907.) An ornamental bamboo of a very low growing, bushy habit, 3 to 5 feet high. Loves a somewhat protected place—for instance, against a wall with southern or eastern exposure. Chinese name *Tsau chu.*" (*Meyer.*)

22580. Prunus armeniaca L. **Apricot.**

From Pangshan, Chihli, China. "(No. 172, Nov. 23, 1907.) A red, medium-sized apricot; said to be very early. Chinese name *Hung sing.*" (*Meyer.*)

22581. Cydonia sp. **Quince.**

From Pangshan, Chihli, China. "(No. 174, Nov. 23, 1907.) A small-fruited quince, the fruits of which are very fragrant and much in demand as room perfumers. Chinese name *Pei mu kua.* Apparently a variety of *Cydonia japonica.*" (*Meyer.*)

22582. Fraxinus sp. **Ash.**

From Tungying, Chihli, China. "(No. 176, Nov. 29, 1907.) A shrubby ash, found in dry and sterile locations. Seems to be different from No. 155 (S. P. I. No. 22572); otherwise, the same remarks apply to it." (*Meyer.*)

22583. Euonymus sp.

From Yenmenkwan, Chihli, China. "(No. 178, Nov. 30, 1907.) A shrubby, deciduous Euonymus, found growing in very dry situations; may be of use as a garden shrub in semiarid regions." (*Meyer.*)

22584. Sambucus sp. **Elder.**

From near Santchako, Chihli, China. "(No. 179, Dec. 1, 1907.) A thrifty species of elder, seen only a couple of times. Loves moist situations." (*Meyer.*)

22571 to 22629—Continued.

22585. Berberis chinensis Poir.

From Shinglung, Chihli, China. "(No. 185, Dec. 2, 1907.) The same as No. 160 (S. P. I. No. 21909) but from a different locality; for remarks, see this number." (*Meyer.*)

22586. Celastrus sp.

From near Tungying, Chihli, China. "(No. 188, Dec. 4, 1907.) A very vigorous species of Celastrus, found growing along rocky trails. May perhaps grow to a very great size; will trail itself into trees or crawl over rocks." (*Meyer.*)

22587. Diervilla sp. **Weigela.**

From near Tungying, Chihli, China. "(No. 190, Dec. 4, 1907.) A vigorous-growing Weigela, bearing small clusters of pale, rose-colored flowers in early summer. Grows in rocky crevices and on steep mountain sides and seems to be able to withstand drought very well. Of use as an ornamental shrub in gardens and parks." (*Meyer.*)

22588. Philadelphus sp.

From Tungying, Chihli, China. "(No. 191, Dec. 4, 1907.) A species of mock orange found growing in dry, rocky locations. May be useful as a garden shrub in dry regions." (*Meyer.*)

22589. Deutzia sp.

From near Tungying, Chihli, China. "(No. 192, Dec. 4, 1907.) Found growing in rocky crevices. Seems to be of a very low growth, 2 to 3 feet. Probably of use as a small garden shrub in semiarid regions." (*Meyer.*)

22590. Spiraea sp.

From Jehol, Chihli, China. "(No. 200, Dec. 11, 1907.) A small, shrubby Spiraea found growing on dry, exposed mountain sides. Of use as a rockery shrub in small-sized gardens in dry regions." (*Meyer.*)

22591. Sambucus racemosa L. (?) **Elder.**

From near Peking, Chihli, China. "(No. 204, Dec. 15, 1907.) A low-growing elder; stands cutting back to the ground every year. Loves to grow on high, dry banks along the fields. May be of use for bank-binding purposes in semiarid regions." (*Meyer.*)

22592. Viburnum opulus L.

From Shinglungshan, Chihli, China. "(No. 205, Dec. 1, 1907.) A few cuttings of the snowball bushes, which were most heavily loaded with bunches of scarlet berries at time of collecting. Seemed to be a more floriferous type than the ordinary one." (*Meyer.*)

22593. Actinidia kolomikta (Maxim.) Rupr. (?)

From near Tungying, Chihli, China. "(No. 207, Dec. 4, 1907.) The small-fruited gooseberry bush. Seems to be a variety of much shorter growth than the ordinary type." (*Meyer.*)

22594. Quercus sp. **Oak.**

From Shinglungshan, Chihli, China. "(No. 834a, Dec. 2, 1907.) Acorns of an oak which bears rather broad leaves, deeply lobed. Probably *Quercus mongolica*. Grows on dry, rocky mountain sides. May be, for this reason, of use as a foresting tree in semiarid climes. Chinese name *Bo li shu.*" (*Meyer.*)

22571 to 22629—Continued.

22595. PYRUS CHINENSIS Lindl. **Pear.**

From Jehol, Chihli, China. "(No. 840a, Dec. 9, 1907.) Obtained from several varieties of cultivated pears, among which were strange types. Some desirable forms may spring up from these northern-grown varieties." (*Meyer.*)

22596. CORYLUS sp. **Hazelnut.**

From near Shinglungshan, Chihli, China. "(No. 841a, Dec. 3, 1907.) A wild hazelnut growing 3 or 4 feet high and covering here and there whole mountain slopes and sloping valleys. Seems to be able to stand drought very well." (*Meyer.*)

22597. DIOSPYROS KAKI L. f. **Persimmon.**

From Pangshan, Chihli, China. "(No. 843a, Nov. 23, 1907.) The very fine persimmon called *Siang shi tse*, scions of which were sent under No. 161 (S. P. I. No. 21910)." (*Meyer.*)

22598. DIOSPYROS KAKI L. f. **Persimmon.**

From Pangshan, Chihli, China. "(No. 843a, Nov. 23, 1907.) A large variety of persimmon of flat shape, occasionally having seeds." (*Meyer.*)

22599. DIOSPYROS KAKI L. f. **Persimmon.**

From Pangshan, Chihli, China. "(No. 844a, Nov. 20, 1907.) The ordinary wild persimmon, called by the Chinese *Gai tsao*, upon which they graft all their seedless persimmons." (*Meyer.*)

22600. PRUNUS sp. **Plum.**

From Pangshan, Chihli, China. "(No. 845a, Nov. 21, 1907.) A flowering plum, said to have double red flowers; often cultivated in temple courts; called *Yu mei tau.* Several varieties will in all probability appear among the seedlings. Budwood previously sent under No. 162 (S. P. I. No. 22576." (*Meyer.*)

22601. VITIS VINIFERA L. **Grape.**

From Lungwa, Chihli, China. "(No. 846a, Dec. 1, 1907.) A wild variety which bears heavy crops of rather large bunches of small, black grapes; edible. Chinese name *Shan poo tau.* Of use as a stock in cold regions." (*Meyer.*)

22602. ACER sp. **Maple.**

From Pangshan, Chihli, China. "(No. 847a, Nov. 23, 1907.) An ornamental maple, attaining a height of about 40 to 50 feet; able to grow in dry regions." (*Meyer.*)

22603. FRAXINUS BUNGEANA DC. **Ash.**

From near Tungying, Chihli, China. "(No. 848a, Dec. 4, 1907.) A small ash tree growing on dry, rocky mountain slopes; well fit for covering barren mountain or hillsides. Chinese name *Koo li sur shu.*" (*Meyer.*)

22604. FRAXINUS BUNGEANA DC. **Ash.**

From Pangshan, Chihli, China. "(No. 849a, Nov. 20, 1907.) A small ash tree found on dry, rocky mountain slopes. Apparently the same as No. 848a (S. P. I. No. 22603). Scions of the tree from which this seed came were sent under No. 155 (S. P. I. No. 22572). Chinese name *Koo li sur shu.*" (*Meyer.*)

22571 to 22629—Continued.

22605. JUGLANS MANDSHURICA Maxim. **Walnut.**

From near Laushang, Chihli, China. "(No. 850a, Dec. 3, 1907.) Apparently a small form of the Manchurian wild walnut." (*Meyer.*)

22606. ZIZYPHUS SATIVA Gaertn. **Chinese date.**

From Jehol, Chihli, China. "(No. 853a, Dec. 9, 1907.) To be used as a stock for improved varieties." (*Meyer.*)

22607. CRATAEGUS sp. **Hawthorn.**

From Laushang, Chihli, China. "(No. 854a, Dec. 3, 1907.) Probably *Crataegus pinnatifida*. May be utilized as stock for the large-fruited varieties. Chinese name of this wild one *Shan li hong*. The seeds may remain dormant for one year or more." (*Meyer.*)

22608. SYRINGA AMURENSIS Rupr. **Lilac.**

From near Laushang, Chihli, China. "(No. 855a, Dec. 3, 1907.) The beautiful white-flowering *Amur* lilac, which is mostly found as a shrub, though it grows in favorable localities into a tree 40 feet tall with a trunk 2 feet in diameter. Stands droughts and sterile soils remarkably well. A good shrub for regions with dry, hot summers and cold winters." (*Meyer.*)

22609. GREWIA PARVIFLORA Bunge.

From Pangshan, Chihli, China. "(No. 856a, Nov. 20, 1907.) A shrub growing from 2 to 10 feet tall, bearing red berries which persist until long into the winter. Grows in dry and rocky locations; as such well fit for gardens in dry regions. Chinese name *Niang nien tchun*. The berries are edible, though not nice." (*Meyer.*)

22610. VIBURNUM OPULUS L.

From Shinglungshan, Chihli, China. "(No. 857a, Dec. 1, 1907.) The branches from which these seeds were picked were sent under No. 205 (S. P. I. No. 22592). See this number for remarks." (*Meyer.*)

22611. DEUTZIA sp.

From Pangshan, Chihli, China. "(No. 858a, Nov. 20, 1907.) A small shrub, found growing on exposed, rocky hill slopes; well fit for rockeries and for gardens in dry regions. Is probably the same species as the one sent under No. 152 (S. P. I. No. 22571)." (*Meyer.*)

22612. RHAMNUS sp.

From Pangshan, Chihli, China. "(No. 859a, Nov. 20, 1907.) A large-leaved, very shrubby Rhamnus, very spiny; found growing between rocks and bowlders. May be of use as a hedge plant in dry situations." (*Meyer.*)

22613. RHAMNUS sp.

From Pangshan, Chihli, China. "(No. 860a, Nov. 20, 1907.) A small-leaved, dwarfy Rhamnus, spiny; found growing between rocks. Fit as a rockery shrub or as a lining bush along pathways in small gardens." (*Meyer.*)

22614. BERBERIS CHINENSIS Poir. **Barberry.**

From Shinglungshan, Chihli, China. "(No. 861a, Dec. 2, 1907.) A low, very spreading bush. Perhaps fit as a sand and bank binder in dry regions. Cuttings sent under Nos. 160 and 185 (S. P. I. Nos. 21909 and 22585)." (*Meyer.*)

22571 to 22629—Continued.

22615. Rosa sp.

From near Shinglungshan, Chihli, China. "(No. 862a, Dec. 3, 1907.) A wild rose of a very spreading habit, having red-colored stems 2 to 3 feet high, very spiny, and bearing many bunches of large scarlet berries. May be of use as a soil binder in rather dry regions." (*Meyer.*)

22616. Celastrus articulatus Thunb.

From Pangshan, Chihli, China. "(No. 863a, Nov. 20, 1907.) A tall climber bearing yellow capsules which burst open when ripe and show the scarlet seeds. Chinese name *Yau go dau tse.*" (*Meyer.*)

22617. Vitis sp.

From Pangshan, Chihli, China. "(No. 864a, Nov. 24, 1907.) Fit for rockeries and along terraces. The same as No. 153 (S. P. I. No. 21907)." (*Meyer.*)

22618. Albizzia sp.

From Pangshan, Chihli, China. "(No. 865a, Nov. 23, 1907.) See No. 768a (S. P. I. No. 21969) for remarks about this tree. This species is quite distinct from *Albizzia julibrissin*, which is much more floriferous and of which the leaves, though much finer pinnated, are much smaller. Bunge seems to have called this one *Acacia macrophylla*, which is declared a synonym of *Acacia lebbek*, which is, however, a totally different plant." (*Meyer.*)

22619. Cassia sp.

From Peking, Chihli, China. "(No. 873a, Nov. 14, 1907.) A cassia, looking like *Cassia marylandica*, bearing long racemes of dark yellow flowers. Used locally as a garden plant. A perennial herb well fit for gardens in dry regions." (*Meyer.*)

22620. Clematis recta mandshurica (Rupr.) Maxim.

From Shinglungshan, Chihli, China. "(No. 875a, Dec. 2, 1907.) An herbaceous perennial, 2 to 3 feet high, bearing one to five erect stems, which terminate in a panicle of rather large, white flowers. Well fit to be improved, when it may become a cut-flower plant of the first order. Of use now as an ornamental garden perennial." (*Meyer.*)

22621. Clematis sp.

From near Yenmenkwan, Chihli, China. "(No. 876a, Nov. 30, 1907.) A creeping clematis running over hedges and stone piles. Seems to be very floriferous; makes woody stems." (*Meyer.*)

22622. (Undetermined.)

From Shutseshan, Chihli, China. "(No. 877a.) Seeds of a Valerianacea, being a perennial herbaceous herb bearing small yellow flowers; ornamental when in a mass. Fit for rockeries and dry situations." (*Meyer.*)

22623. Salvia sp.

From near Tungying, Chihli, China. "(No. 878a, Dec. 4, 1907.) A shrubby perennial, 3 to 4 feet high, very floriferous; found growing in very rocky locations. May be of use as a honey plant in semiarid regions." (*Meyer.*)

22571 to 22629—Continued.

22624. Asparagus sp.

From near Laushang, Chihli, China. "(No. 880a, Dec. 30, 1907.) Wild asparagus. A tall form, 3 to 4 feet high, growing between grass, having zigzag stems and bent-down branches. Of use as an ornamental garden plant." (*Meyer.*)

22625. Asparagus sp.

From near Laushang, Chihli, China. "(No. 881a, Dec. 3, 1907.) Wild asparagus. A small form 1 foot high; otherwise, apparently the same as No. 880a (S. P. I. No. 22624)." (*Meyer.*)

22626. Asparagus sp.

From Shinglungshan, Chihli, China. "(No. 882a, Dec. 2, 1907.) Wild asparagus; found growing on the mountain tops under the shade of pine trees. Has straight stems." (*Meyer.*)

22627. Lilium sp.

From near Shinglungshan, Chihli, China. "(No. 883a, Dec. 1, 1907.) A small lily, 3 feet high, found growing between grass." (*Meyer.*)

22628. (Undetermined.)

From Shinglungshan, Chihli, China. "(No. 884a, Dec. 3, 1907.) A leguminous plant found growing between grasses." (*Meyer.*)

22629. Cydonia japonica (Thunb.) Pers. **Quince.**

From Peking, Chihli, China. "(No. 899a, Dec. 24, 1907.) A small-fruited quince having a very spicy odor. The fruits are sold as room perfumers. Chinese name *Mu li.*" (*Meyer.*)

22630. Castilla sp.

From Ancon, Canal Zone, Panama. Presented by Mr. Henry F. Schultz, through Mr. O. W. Barrett. Received April 17, 1908.

"Seed from our best rubber-producing trees." (*Schultz.*)

22631 and 22632. Gossypium barbadense L. Cotton.

From Cairo, Egypt. Purchased from Mr. George P. Foaden, Khedivial Agricultural Society. Received April 15, 1908.

22631. *Jannovitch.* (For description see S. P. I. No. 3991.)

22632. *Mit Afifi.* (For description see No. 3992.)

See also Bulletin No. 62 of the Bureau of Plant Industry for descriptions.

22633 to 22635.

From Sheklung, Kwongtung, China. Presented by Mr. A. J. Fisher, American Presbyterian Mission. Received April 3, 1908.

22633 and 22634. Glycine hispida (Moench) Maxim. **Soy bean.**

22633. Yellow. Similar in appearance to *Acme*, No. 14954, but seed is a trifle larger.

22634. Black. Seed flatter than any other of the same size received from China.

22635. Vigna unguiculata (L.) Walp. **Cowpea.**

Chinese Red. Apparently identical with No. 17328, which is the progeny of No. 6557.

Varietal descriptions of the above were made by Mr. H. T. Nielsen.

22637 to 22640. PISUM ARVENSE L. **Canada field pea.**

From Guelph, Canada. Presented by Prof. C. A. Zavitz, Ontario Agricultural College, through Mr. C. V. Piper. Received April 16, 1908.

22637. *Multipliers.*
22638. *Clamart.*
22639. *White Scimitar.*
22640. *Canadian Beauty.*

22641 and 22642.

From Paris, France. Purchased from Vilmorin-Andrieux & Co. Received April 8, 1908.

22641. BRYONIA DIOICA Jacq.

"An herbaceous, climbing member of the pumpkin family, interesting on account of the handsome foliage with development of remarkably long tendrils. The large perennial root, sliced and dried, appears on the drug market under the name of Bryonia, and is a very highly valued drug, especially in homeopathic medicine." (*R. H. True.*)

22642. ECBALLIUM ELATERIUM (L.) A. Rich.

"An herbaceous, hairy annual, producing a trailing vine and characteristic cucurbitaceous inflorescence. The fruit on ripening undergoes a process of softening, which results finally in the splitting of the coating of the fruit and the squirting out of the seeds and soft pulp. Hence the name 'Squirting cucumber.' The drug elaterium is obtained from the juice pressed from the nearly ripe fruit. This juice after straining deposits an opaque grayish sediment which forms the characteristic elaterium cakes seen in the commercial article." (*R. H. True.*)

22643. PENNISETUM AMERICANUM (L.) Schum. **Pearl millet.**

From Cape Town, South Africa. Presented by Dr. E. A. Nobbs, Department of Agriculture. Received April 17, 1908.

"Seed of *N'yout*, pronounced knee-out; is extensively grown in Bechuanaland and all over Rhodesia; is used as a native food and is also given to mules. It is similar in character to Kafir corn but finer and smaller, and I think may be of considerable value." (*Nobbs.*)

22644 to 22649.

From Hangchow, Chehkiang, China. Presented by Mr. John L. Stuart. Received April 18, 1908.

The following seeds, varietal descriptions by Mr. H. T. Nielsen:

22644 to 22646. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

22644. Smoky yellow. Looks like it might possibly be a mixture.

22645. Greenish yellow. Similar in appearance to *Haberlandt*, No. 17263.

22646. Yellow. Practically identical with No. 18619.

22647. VIGNA SESQUIPEDALIS (L.) W. F. Wight.

Black.

22648. VIGNA SESQUIPEDALIS (L.) W. F. Wight.

Red.

22649. MEDICAGO DENTICULATA Willd. **Bur clover.**

22650 to 22652.

From Shanghai, Kiangsu, China. Presented by Rev. J. M. W. Farnham, Chinese Tract Society. Received April 15, 1908.

The following plants:

22650. AMYGDALUS PERSICA L. **Peach.**

Shanghai. "These peaches are called the *Honey* peach, and I think are very fine." (*Farnham.*)

22651. CITRUS AURANTIUM SINENSIS L. **Sweet orange.**

Canton. "If you have not this variety in America, it would be a great boon to introduce it.

"Mrs. Farnham and I have eaten oranges in many parts of the world, in southern Europe, taken fresh from the trees outside of Jafa, the famous *Navel* orange of California, and elsewhere, and are of the opinion that the *Canton* is far the most delicious. There is a very long season, from, say, December to April, and it seems to me that there must be slightly different varieties, resembling the varieties of apples that come on through the different seasons, though with far less difference." (*Farnham.*)

22652. CITRUS AURANTIUM SINENSIS L. **Sweet orange.**

Swatow. "The Swatow oranges are much admired by some. They grow to a large size and are a deep orange color, with a soft skin that is easily removed even without a knife. The lobes easily fall apart; they are covered with a thin silky skin which incloses the very sweet pulp and juice. You may like to call it the *Sweet* orange, or, as the Chinese say, *Honey* orange, or, better still, *Swatow*, as that is, I understand, the only place where it is raised." (*Farnham.*)

22653 and 22654.

From Grahamstown, Cape Colony, South Africa. Presented by Dr. S. Schönland, Albany Museum. Received April 11, 1908.

22653. ANDROPOGON SORGHUM (L.) Brot. **Kafir.**

Red.

22654. PASPALUM DILATATUM Poir. **Large water grass.**

22655. QUERCUS SUBER L. Cork oak.

From Barcelona, Spain. Presented by Mr. Peter Campbell, the Nairn Linoleum Company, Kearny, N. J. Received April 18, 1908.

"These acorns were procured for the purpose of getting on hand a large stock of plants which can be used in experiments in establishing groves of cork oaks in this country as a possible commercial source of cork." (*Fischer.*) (See S. P. I. No. 21732 for other importation.)

22656. ERAGROSTIS ABYSSINICA (Jacq.) Schrad. Teff.

From province of Harrar, Abyssinia, Africa. Presented by Mr. Robert P. Skinner, American consul-general, Marseille, France. Received April 11, 1908.

"This seed was produced in the region of Harrar at an altitude of 1,800 meters (5,905 feet). Teff is found throughout the province of Harrar at altitudes varying from 1,000 to 2,000 meters (3,280 feet to 6,561 feet), and is sown in various kinds of soil." (*Skinner.*) (See Nos. 17094 and 17095 for description.)

22657 to 22661.

From Bucharest, Roumania. Presented by Mr. Horace G. Knowles, American minister. Received April 2, 1908.

22657 and 22658. CITRULLUS VULGARIS Schrad. **Watermelon.**

22657.

"Seed from a small, round, green, and thin-skinned melon about the size of an average grapefruit and as sweet as an orange. Its shape and size—just large enough for one person—and delicious flavor would make it immensely popular for serving at clubs, hotels, and restaurants." (*Knowles.*)

22658.

"Another variety of small melon." (*Knowles.*)

22659 to 22661. CUCUMIS MELO L. **Muskmelon.**

"These yellow melon seeds are from the most delicious muskmelons or cantaloupes I ever tasted, and the flavor is as far ahead of the *Rockyford* as the *Rockyford* is ahead of the *Jersey* cantaloupe. If these melons could be grown in the United States to the perfect state they attain here, they would make an invaluable addition to the fruits of our country." (*Knowles.*)

22659.

"Oblong, yellow melon. Thin skin, thick meat, and very sweet." (*Knowles.*)

22660.

"Large, round, yellow melon. Firm meat and deliciously sweet. Was fully ripe October 1 and was grown in light soil with plenty of sun." (*Knowles.*)

22661.

"Another variety of round, sweet, yellow melon." (*Knowles.*)

22662. CHAYOTA EDULIS Jacq. **Chayote.**

From New Orleans, La. Purchased from the J. Steckler Seed Company. Received April 22, 1908.

"Fruits of a smooth variety of chayote secured for distribution in the Southern States with the object of encouraging its culture for the market." (*Fischer.*)

22663. RUBUS sp. **Raspberry.**

From Shanghai, Kiangsu, China. Presented by Rev. J. M. W. Farnham, Chinese Tract Society. Received April 21, 1908.

"Plants I have found growing wild on the rocky and sandy mountain side, but in good soil, 2,000 feet above the sea." (*Farnham.*)

22664 to 22669.

From Paris, France. Presented by Prof. Y. Costantin, director, Museum of Natural History, rue Buffon 61. Received April 24, 1908.

22664. ANDROPOGON HALEPENSIS (L.) Brot.

22665. PANICUM sp. (?)

22666. ARRHENATHERUM ELATIUS TUBEROSUS (Gilib.) Skeels. (AVENA TUBEROSA Gilib.)

22664 to 22669—Continued.

22667. ANTHEPHORA HERMAPHRODITA (L.) Kuntze.

22668. PHLEUM PANICULATUM Huds.

22669. PHLEUM ARENARIUM L.

22670. CITRUS AURANTIUM L. **Bigarade.**

From Yokohama, Japan. Purchased from the Yokohama Nursery Company. Received April 24, 1908.

Natsu mikan. "The *Natsu mikan*, or 'summer orange,' is needed here as a successor of grapefruit at the season when there is nothing at all to take the place of that most refreshing fruit. Nothing equals the piercing, delicious acidity of *Natsu mikan*, which is decidedly a sour orange, not in the least like a lemon or a lime. Nothing is so refreshing on a hot summer morning as half of a *Natsu mikan*, and orangeade made of *Natsu mikan* is different from lemonade and much better.

"I remember gratefully the plates heaped with peeled sections of *Natsu mikan*, with the accompanying plates of sugar, that are offered one at private houses and at monasteries on Japanese summer days.

"It seems to me that the *Natsu mikan* is more often seen on fruit stands in Tokyo than formerly, and more often offered to the foreigner. The largest and finest, they say, come from Yamaguchi prefecture, at the foot of the Inland Sea.

"It is a great improvement on the Chinese pomelo, which is so often dry and tasteless, and I shall be glad when we can have it throughout the summer in America." (*Eliza R. Scidmore.*) (See No. 9268 for previous introduction and further description.)

22671 to 22696.

From Peking, Chihli, China. Received through **Mr. Frank N. Meyer**, agricultural explorer, April 20, 1908.

A collection of seeds and cuttings, as follows:

22671. ABIES sp. **Fir.**

From Peisantse Temple, Wutaishan, Shansi, China. "(No. 256, Feb. 21, 1908.) A very tall growing fir, having small light green needles and light-colored, round, oblong cones. Found growing at 6,000 to 7,000 feet altitude. Chinese name *Tchien shu.*" (*Meyer.*)

22672. ABIES sp.

From Tchaillingtse Temple, Wutaishan, Shansi, China. "(No. 257, Feb. 25, 1908.) A medium-tall fir, having large, curved needles with a bluish bloom on them, and bearing long, tapering cones of a chocolate-brown color. Collected at an altitude between 8,000 and 9,000 feet. Chinese name *Tchien shu.*" (*Meyer.*)

22673. PINUS sp.

From Tchenghaitse Temple, Wutaishan, Shansi, China. "(No. 258, Feb. 27, 1908.) A tall-growing pine, fit for forestry purposes. Chinese name *Sung shu.*" (*Meyer.*)

22674. LARIX sp. **Larch.**

From Tchaillingtse Temple, Wutaishan, Shansi, China. "(No. 259, Feb. 25, 1908.) A larch of medium-sized height, growing on sterile mountain sides at very high elevations, 7,000 to 9,000 feet. Fit as a forestry tree

22671 to 22696—Continued.

in cold-wintered regions, as it grows on the northern exposed mountain slopes, where the snow does not melt until way into May. Chinese name *Tsai shu.*" (*Meyer.*)

22675. Syringa villosa Vahl. (?) **Lilac.**

From Nansantse Temple, Wutaishan, Shansi, China. "(No. 269, Feb. 26, 1906.) A lilac found growing at high elevations, 7,000 to 8,000 feet. Said to bear large panicles of white flowers. Chinese name *Sar shu.*" (*Meyer.*)

22676. Crataegus sp. **Hawthorn.**

From Tchenghaitse Temple, Wutaishan, Shansi, China. "(No. 271, Feb. 27, 1908.) A hawthorn growing into a small tree having very large spines; even the trunk is covered with branched spines. Chinese name *Ling ching tse.*" (*Meyer.*)

22677. Rhododendron sp.

From Shanfengko, Shansi, Wutaishan region, China. "(No. 273, Feb. 29, 1908.) A rhododendron of dense, shrubby growth, 4 to 5 feet high, growing on cliffs at about 5,000 feet altitude; apparently rare." (*Meyer.*)

22678. Ulmus sp. **Elm.**

From Yento, Shansi, China. "(No. 275, Mar. 1, 1908.) A densely branched elm of shrubby growth, occasionally growing into a small tree; found growing on a sunny rocky mountain slope at about 4,000 feet altitude." (*Meyer.*)

22679. Abies sp. **Fir.**

From Talautse, Shansi, China. "(No. 277, Mar. 1, 1908.) A fir of a peculiar drooping appearance; found growing in an old temple court; only one specimen. Chinese name *Tchien shu.*" (*Meyer.*)

22680. Pinus sp. **Pine.**

From Tongdjautchang, Shansi, China. "(No. 278, Mar. 2, 1908.) A pine of very dense foliage and growing into a stately tree of imposing appearance; rare." (*Meyer.*)

22681. Rosa xanthina Lindl. **Rose.**

From Tsintse, Shansi, China. "(No. 288, Mar. 9, 1908.) A wild yellow rose growing in large masses on dry and sterile mountain slopes. Will in the future prove to be the best grafting stock for high-class roses in sterile and arid locations; is used by the Chinese as a stock for roses in pots. Chinese name *Moo ro tse.*" (*Meyer.*)

22682. Ulmus sp. **Elm.**

From Tsintse, Shansi, China. "(No. 290, Mar. 9, 1908.) An elm of shrubby growth, which becomes a small tree when left alone; has small Prunus-like leaves, dense branches, ashy white bark, and very hard, tough wood, which is highly appreciated as construction material for cart wheels. Grows in dry, rocky situations. Very well fit, as a small tree, for rocky locations and Japanese gardens. Can easily be dwarfed. Probably a new species. Chinese name *Yeh yü shu.*" (*Meyer.*)

22683. Zizyphus sativa Gaertn. **Chinese date.**

From Tsintse, Shansi, China. "(No. 293, Mar. 1, 1908.) A jujube (Chinese date) tree, bearing large, oblong fruits of shining red color,

22671 to 22696—Continued.

which are mainly used as a delicatesse, after having been soaked in weak Chinese spirits for a couple of months. They have a hard skin and are bad for the bowels. The trees can be planted close together (6 to 8 feet) and do not apparently attain great size. Chinese name *Hu ping tsao*, meaning bottle jujube. Is considered locally the best of the different varieties grown." (*Meyer.*)

22684. ZIZYPHUS SATIVA Gaertn. **Chinese date.**

From Tsintse, Shansi, China. "(No. 294, Mar. 10, 1908.) A jujube (Chinese date) having medium-sized, red-colored, oblong fruits which taper toward the end. The trees grow to a large size, and when old have hardly any side branches on the main limbs. Chinese name *Mu shing hong tsao;* might be called 'pointed jujube.'" (*Meyer.*)

22685. ZIZYPHUS SATIVA Gaertn. **Chinese date.**

From Tsintse, Shansi, China. "(No. 295, Mar. 10, 1908.) A jujube (Chinese date) said to have red oblong fruits, which crack easily when falling down. Trees medium sized. Chinese name *Tsui ling tsao*, meaning 'fragile jujube.' Said to be a very poor keeper." (*Meyer.*)

22686. ZIZYPHUS SATIVA Gaertn. **Chinese date.**

From Tsintse, Shansi, China. "(No. 296, Mar. 10, 1908.) A jujube (Chinese date) tree which grows very large and spreads out very much, bearing small fruits of oblong shape, red color, and of a melting, sweet taste; can not be kept long. Chinese name *Lang tsao.* Might be called 'melting jujube.'" (*Meyer.*)

22687. SYRINGA sp. **Lilac.**

From Tsintse, Shansi, China. "(No. 297, Mar. 10, 1908.) A very floriferous lilac, growing often as a little tree; found on dry mountain slopes. Chinese name *Shau ting hsien.*" (*Meyer.*)

22688. AVENA NUDA INERMIS (Koern.) Asch. & Graeb. **Oat.**

From Tchailingtse Temple, Wutaishan, Shansi, China. "(No. 927a, Feb. 25, 1908.) A hull-less oat found growing at 8,000 to 9,000 feet elevation. May be of use in the elevated sections of the Rocky Mountain regions. Chinese name *Yoh ma.*" (*Meyer.*)

22689. HORDEUM DISTICHON NUDUM L. **Hull-less barley.**

From Tchailingtse Temple, Wutaishan, Shansi, China. "(No. 928a, Feb. 25, 1908.) A hull-less barley found growing at 8,000 to 9,000 feet elevation. Is very rare in this region and might have been brought in from Mongolia by the Mongolian pilgrims, who visit the Wutaishan region every year by the thousands. May be of great value in the short-summered section of the United States. Chinese name *Tsao ma.*" (*Meyer.*)

22690. CANNABIS SATIVA L. **Hemp.**

From Tongchör, Shansi, Kwohsien District, China. "(No. 932a, Mar. 4, 1908.) Grown in mountain valleys; considered to be the best variety of hemp of the Shansi Province, and sold in all of the towns and cities for string and rope manufacture. Chinese name *Shan ma tse.*" (*Meyer.*)

22691. PINUS BUNGEANA Zucc. **Pine.**

From Taiyuanfu, Shansi, China. "(No. 934a, Mar. 13, 1908.) Sold on the streets as a delicatesse, and said to come from the mountains of

22671 to 22696—Continued.

northern Honan. Chinese name *Sung tse.* Apparently the same as No. 797a (S. P. I. No. 21997)." (*Meyer.*)

22692. ROSA sp. **Rose.**

From Nausantse Temple, Wutaishan, Shansi, China. "(No. 935a, Feb. 28, 1908.) A tall-growing, bushy, red-flowered rose; found in thickets on the mountain slopes. May be of use as a grafting stock for standard roses. Chinese name *Yeh hong mae kwei hua.*" (*Meyer.*)

22693. ROSA XANTHINA Lindl. **Rose.**

From Tsintse, Shansi, China. "(No. 936a, Mar. 9, 1908.) A wild yellow rose, called *Moo ro tse* by the Chinese. For further remarks see No. 288 (S. P. I. No. 22681)." (*Meyer.*)

22694. BRASSICA OLERACEA L. **Cabbage.**

From Wutaishan, Shansi, China. "(No. 937a, Feb. 28, 1908.) A cabbage, flat like our own western cabbages, but growing on a high stem. Can be kept frozen hard throughout the winter, and, after having been washed with boiling water, can be served with oil and vinegar as an excellent salad, tasting quite sweet. Grows at 4,000 to 7,000 feet altitude. Fit for the northern and the alpine regions of the United States. Chinese name *Whe tse pai tsai.*" (*Meyer.*)

22695. COTONEASTER INTEGERRIMA Medic.

From Nausantse Temple, Wutaishan, Shansi, China. "(No. 938a, Feb. 26, 1908.) A shrub growing in shady locations on the mountain slopes; bears black berries; height 3 to 10 feet, according to amount of light and exposure. Hard wooded. Chinese name *Shan he tsao.*" (*Meyer.*)

22696. SYRINGA sp. **Lilac.**

From mountains near Tsintse, Shansi, China. "(No. 944a, Mar. 10, 1908.) A very floriferous lilac found on dry mountain slopes; grows often to be a little tree. Cuttings sent under No. 297 (S. P. I. No. 22687). Chinese name *Shau ting hsien.*" (*Meyer.*)

22704 to 22714.

From Saigon, Cochin China. Presented by Mr. Jacob E. Conner, American consul. Received April 21, 1908.

22704. SAGUERUS PINNATUS Wurmb.

22705. ONCOSPERMA sp.

22706. ARCHONTOPHOENIX ALEXANDRAE (F. Muell.) Wend. & Drude.

22707. RHAPIS FLABELLIFORMIS L'Herit.

22708. DYPSIS PINNATIFRONS Mart. (?)

22709. SABAL sp.

22710. CARYOTA MITIS Lour. (?)

22711. LICUALA PELTATA Roxb. (?)

22712. ARECA OLERACEA Jacq.

22713. ELAEIS GUINEENSIS Jacq.

22714. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

Yellow.

22715 to 22730. VIGNA UNGUICULATA (L.) Walp. **Cowpea.**

From Clemson College, S. C. Presented by Prof. C. L. Newman. Received April, 1908.

Professor Newman made the hybrids indicated in the following list. The selections were also made by him. Descriptive notes by Mr. H. T. Nielsen.

22715.

(Newman's No. 2.) Evidently a hybrid between *Blackeye* and *Taylor;* seed fully as large as *Taylor.*

22716. *Blackeye* × *Extra Early Blackeye.*

(Newman's No. 4.) Probably *Blackeye* × *Black.* Looks like *Sport,* No. 17427, and *Watson's Hybrid,* No. 17425.

22717. *California Blackeye* × *Taylor.*

(Newman's No. 9.) Looks like No. 22715, but seed is smaller.

22718. *Blackeye* × *Black Bunch.*

(Newman's No. 12.) Not distinguishable from No. 22716.

22719. *Blackeye* × *Black Bunch.*

(Newman's No. 10.) Apparently identical with Nos. 22716 and 22718.

22720. *Blackeye* × *Black.*

(Newman's No. 13.) Looks like *Holstein,* No. 17327.

22721. *Blackeye* × *Extra Early Blackeye.*

(Newman's No. 16.) Appears identical with Nos. 22716, 22718, and 22719.

22722. Red.

(Newman's No. 26.) A selection from *Clay.*

22723. *Clay.*

(Newman's No. 27.) A selection from *Clay.*

22724. *Clay.*

(Newman's No. 28.) A self-seeding strain.

22725. *Holstein.*

(Newman's No. 43.) Seed exactly like No. 22720.

22726. *Taylor* × *Large White Spot.*

(Newman's No. 50.) Looks exactly like No. 22717.

22727. *Taylor* × *Browneye.*

(Newman's No. 51.) Has but very slight markings of the *Taylor* variety.

22728. *Warren's New Hybrid* (?).

(Newman's No. 53.) Probably a hybrid between *Warren's New Hybrid* and one of the *Lady* varieties; is similar in appearance to *Southdown,* No. 17339, but the seed is a little smaller.

22729. *Warren's Extra Early* × *Sugar Crowder.*

(Newman's No. 57.) This is probably the same as our No. 17422, which is also a hybrid between these two.

22730. *Whippoorwill* × *Lady.*

(Newman's No. 64.) Apparently identical with *Guernsey,* No. 17408.

22731 to 22737.

From Nimboli, Post Mangrul-Dastgir, District Amraoti, Berars, India. Presented by Mr. Anant Sitaram Dhavale, through Mr. C. V. Piper. Received April 24, 1908.

The following seeds:

22731. CAJAN INDICUM Spreng.

"*Tur.* A legume food crop. The dry fodder is generally fed to cattle." (*Dhavale.*)

22732. INDIGOFERA GLANDULOSA Wendl.

"*Divale.* An extraordinary leguminous plant; grows on good soil and shows the greatest number of root nodules. Used only for green manure." (*Dhavale.*)

22733. SESBAN BISPINOSA (Jacq.) Steud. (AESCHYNOMENE BISPINOSA Jacq.)

"*Shevari.* A legume forage crop; grown under irrigation; very nourishing to sheep and bullocks when fed in green state." (*Dhavale.*)

22734. (Undetermined.)

"*Shevari.* A legume forage crop; grown under irrigation; very nourishing; is fed to bullocks in green state." (*Dhavale.*)

22735. SESBAN AEGYPTIACA Pers. (?)

"*Savara.* A legume forage crop; is fed to bullocks and sheep in green state. Grows wild." (*Dhavale.*)

22736. CICER ARIETINUM L.

"*Harbhara.* A legume food crop; is fed to horses in green state, and the seed also when dry. Horses love it most." (*Dhavale.*)

22737. PSORALEA CORYLIFOLIA L.

"*Bavachi.* A legume plant; is fed to buffaloes; very rarely bears root nodules." (*Dhavale.*)

22738. PISUM SATIVUM L. **Pea.**

From Boston, Mass. Received through R. & J. Farquhar & Co., April 27, 1908.

"To be used for breeding purposes." (*Young.*)

22739. CUCURBITA PEPO L. **Squash.**

From Shanghai, Kiangsu, China. Presented by Rev. J. M. W. Farnham, Chinese Tract Society. Received April 17, 1908.

"A fine winter squash (Chinese)." (*Farnham.*)

22740 and 22741. COLOCASIA spp. **Taro.**

From Paramaribo, Dutch Guiana. Presented by Dr. C. J. J. Van Hall, through Mr. O. W. Barrett. Received April 28, 1908.

The following tubers:

22740.

"*Hindoe-taya.* This has been imported by British Indian coolies." (*Van Hall.*)

22740 and 22741—Continued.

22741.

"*Agoe-taya.* (Agoe=swine.) Is a very coarse variety." (*Van Hall.*)

"These two *taya* varieties are the only new ones I found in this colony." (*Van Hall.*)

22742. TOLUIFERA PEREIRAE (Klotz) Baill.

From San Salvador. Presented by Mr. José C. Zeledon, Botica Francesa, San José de Costa Rica. Received April 28, 1908.

"The tree from which the Peruvian balsam is obtained. Since the plant has so much economic importance commercially, it may prove interesting." (*Zeledon.*)

22743. CITRULLUS VULGARIS Schrad. **Watermelon.**

From Panama. Presented by Miss M. M. Childs, of the United States Forest Service. Received April 29, 1908.

"This melon is of average size, lemon-yellow inside, and its flavor somewhat resembles the hickory nut. The rind is very hard and white. The pulp is much softer than the ordinary watermelon, and its juice is used to flavor ice cream. Considered very fine by Americans at Panama, and called by them *Panamanian* watermelon." (*Childs.*)

22744. CANANGA ODORATA (Lam.) Hook. f. & Thoms. **Ilang ilang.**

From Manila, P. I. Presented by Mr. H. N. Whitford, chief, Division of Forest Investigations, Bureau of Forestry, Department of the Interior. Received April 21, 1908.

"The ilang ilang grows here (Saigon, Cochin China) in some profusion, but it has not yet been cultivated to any considerable commercial extent, as it might be, for its rare perfume. It is a handsome tree, symmetrical and stately, reaching a height of 50 feet or more. It has a smooth, hard, grayish bark resembling that of the beech. It flowers in April and May, or perhaps even earlier. The long, strap-like, yellowish petals give out a rich, spicy fragrance, somewhat resembling that of cinnamon and very pronounced just after a rain. It grows very well in this hard, black soil of Cochin China, but I am unable to say just what soil it prefers." (*Conner.*) (For further description see S. P. I. Nos. 3793, 3897, and 20908.)

22745. ARALIA RACEMOSA L. **Spikenard.**

From North Clarendon, Vt. Presented by Mr. James Barrett. Received April 29, 1908.

"Natural habitat is a partly shady place where it can have leaf mold to feed on." (*Barrett.*) (For further description see S. P. I. No. 21658.)

22746 to 22753.

From Buitenzorg, Java. Presented by Dr. M. Treub, director, Department of Agriculture. Received April 27, 1908.

Seed of each of the following:

22746. VIGNA SESQUIPEDALIS (L.) W. F. Wight.

"Speckled, reddish brown seeds, similar to No. 21562, but seeds are shorter." (*Nielsen.*)

22746 to 22753—Continued.

22747. VIGNA SESQUIPEDALIS (L.) W. F. Wight.

"Reddish brown seeds, lighter in color than No. 22746." (*Nielsen.*)

22748. CLITORIA HETEROPHYLLA Lam.

22749 to 22753. CLITORIA TERNATEA L.

22749. Fl. *alba*.

22750. Fl. *atrocoerulea.*

22751. Fl. *Bryni.*

22752. Fl. *coerulea.*

22753. Fl. *violacea.*

22754. POA EAQUATORIENSIS Hack. (?)

From Ecuador. Presented by Mr. L. Ordonez, 537 Harrison street, San Francisco, Cal., through Mr. C. V. Piper. Received April 20, 1908.

"This is considered one of the best native grasses of Ecuador; grows very well on light soil with irrigation, but thrives also on dry land." (*Ordonez.*)

22755. BRASSICA RAPA L. **Turnip.**

From Helsingfors, Finland. Purchased from Mr. V. F. Sagulin. Received April 29, 1908.

Petrowski. "We grew this turnip last season at the stations at Sitka, Rampart, and Copper Valley, and at none of these places was this variety of turnip attacked by the pest (root maggot), although other varieties growing alongside were badly affected." (*Prof. C. C. Georgeson, Alaska Agricultural Experiment Station.*) (For other introduction see No. 19554.)

22756 and 22757. BRASSICA RAPA L. **Turnip.**

From Helsingfors, Finland. Presented by Mr. V. F. Sagulin. Received April 25, 1908.

22756. *Flat Round Yellow Finnish.*

22757. *Yellow Round Red-Top.*

22758 to 22761.

From India. Presented by T. F. Main, esq., Deputy Director of Agriculture, Poona, Bombay, India. Received April 28, 1908.

From Dharwar District:

22758. VIGNA CATJANG (Burm.) Walp.

From Surat District:

22759. VIGNA CATJANG (Burm.) Walp.

Similar in appearance to S. P. I. No. 21292.

22760. VIGNA CATJANG (Burm.) Walp.

22761. PHASEOLUS ACONITIFOLIUS Jacq. **Moth bean.**

22762 and 22763. OLEA EUROPAEA L. **Olive.**

From Sfax, Tunis. Purchased from Chatel & Jacquemart. Received April 29, 1908.

Chemlali. Truncheons and seed. (See S. P. I. No. 13567 for description.)

22764. ANDROPOGON SERICEUS R. Br.

From Pretoria, Transvaal, South Africa. Presented by Prof. J. Burtt Davy, government agrostologist and botanist, Transvaal Department of Agriculture. Received May 1, 1908.

"*New South Wales Bluegrass.* The seed is this year's crop grown in the Transvaal." (*Davy.*)

22765 to 22770. COLOCASIA ESCULENTA (L.) Schott. **Taro.**

From Buitenzorg, Java. Presented by Dr. M. Treub, director, Department of Agriculture, through Mr. O. W. Barrett. Received May 1, 1908.

The following tubers. The nomenclature is mainly that of Hasskarl, Cat. Pl. Hort. Bogor., 55. The Malay names are also quoted.

22765. Variety *polyrrhiza* Hsskl., subvariety *viridis.* "Kimpoel idjoh."

22766. Variety *monorrhiza* Hsskl., subvariety *rubri-nervis.* "Talus romah banteng."

22767. Variety *monorrhiza* Hsskl., subvariety *rubra.* "Talus lampoeng-merah."

22768. Variety *monorrhiza* Hsskl., subvariety *rubra.* "Talus bajabon."

22769. Variety *monorrhiza* Hsskl., subvariety "Talus goenoeng tjisalak."

22770. Variety *monorrhiza* Hsskl., subvariety "Talus kekes."

22771. MUSA PARADISIACA L. **Banana.**

From Port of Spain, Trinidad, British West Indies. Presented by Dr. E. André, through Mr. O. W. Barrett. Received May 1, 1908.

"This banana is of the small kind known here as *Fig.*" (*Andre.*)

"A small ornamental banana which has small fruits and numerous seeds." (*Barrett.*)

22772 to 22774.

From Port of Spain, Trinidad, British West Indies. Presented by Dr. E. André. Received May 1, 1908.

22772. TOUNATEA SIMPLEX (Vahl.) Taub.

"A small, smooth-barked tree, branching like an elm. Leaves short petioled, alternate, 3 inches long, smooth; veins on under surface yellowish. Flowers borne in three-flowered racemes, in axils of leaves, at the tips of the branches. Corolla 1½ inches long, pale yellow. Wood hard and fine grained; used for lathe work." (*H. Pittier.*)

22773. GLIRICIDIA MACULATA H. B. & K.

"An unarmed tree, with alternate, compound leaves. Flowers resembling those of black locust in size, but pink." (*H. B. & K.*)

22774. CYNOMETRA TRINITENSIS Oliv.

"A small tree of the senna family. Leaves alternate, compound, of two obliquely oblong leaflets, 3 to 4 inches long. Flowers in small, many-flowered, axillary, sessile clusters. Fruit a one-seeded, globular legume, 1 to 2 inches in diameter." (*Oliv.*)

22775 to 22778.

From Asmara, Eritrea, North Africa. Presented by the director, Colonial Agricultural Experiment Station. Received April 29, 1908.

22775. JUNIPERUS PROCERA Hochst.

22775 to 22778—Continued.

"A handsome tree, growing 25 to 40 meters in central Africa, its native habitat, and its wood is useful in the manufacture of various small articles." (*Wight.*)

22776. OXYTENANTHERA ABYSSINICA (Rich.) Munro.

22777. ACACIA LAHAI Steud. & Hochst.

22778. ALBIZZIA ANTHELIMINTICA (A. Rich.) Brongn.

22779. CITRUS sp.

From Algiers, Algeria. Presented by Dr. L. Trabut, government botanist. Received April 27, 1908.

"*Zenboua.* Large tree; spiny; large leaves with a short petiole, slightly winged. Fruit large, depressed, terminated by a flat protuberance. It has been propagated at El-Kantara, in the oasis, where it attains large dimensions. It is very nearly related to the 'Pomme de Adam' and the rough lemon of Florida.. Resists gummosis at El-Kantara, near Biskra. Would constitute a good grafting stock for the oasis." (*Trabut.*)

22781 to 22783.

From Georgetown, British Guiana. Presented by Mr. A. W. Bartlett, government botanist, Botanic Gardens, through Mr. C. V. Piper. Received May 1, 1908.

The following seeds:

22781. SOPHORA TOMENTOSA L.

A small tree, with large, odd-pinnate leaves. Flowers yellow, in stout racemes, about 6 inches long. Distribution, tropical shores throughout the world. (*Extract from H. Trimen, Handb. Fl. Ceyl.*)

22782. VINCA ROSEA L. **Madagascar periwinkle.**

"Tender, erect subshrub with oblong leaves. Flowers rosy or white, often with a pink eye; produced all summer. Sometimes called Cape periwinkle and *Old Maid.*" (*Bailey, Cycl. Amer. Hort.*)

22783. CAMPOMANESIA CERASOIDES (Cambess.) A. Gray.

"A shrub with opposite, elliptical, petioled leaves, bearing white flowers in the axils. Fruit the size of a cherry. A native of Brazil." (*Cambessedes.*)

22784. MEDICAGO SATIVA L. Alfalfa.

From Alicante, Spain. Procured through the consular agent at Alicante, by Mr. R. L. Sprague, American consul, Gibraltar, Spain. Received May 4, 1908.

"*Elche.* This variety, called in Spanish the 'broad-leaved of Elche,' was called to my attention by Doctor Trabut, of Algiers. It is supposed by him to be a distinct strain of alfalfa which is grown quite generally near the town of Elche, Spain." (*Fairchild.*)

22785 and 22786.

From Belize, British Honduras. Presented by Mr. E. J. F. Campbell, superintendent, Botanic Station. Received April 30, 1908.

22785 and 22786—Continued.

22785. (Undetermined.)

"Indigenous velvet bean." (*Campbell.*)

22786. (Undetermined.)

"Indigenous handsome blue-flowered legume." (*Campbell.*)

22787. ANDROPOGON SORGHUM (L.) Brot. **Sorgo.**

From Hoxie, Kans. Presented by Mr. M. G. Blackman, through Mr. Carleton R. Ball. Received May 1, 1908.

"*Club Head.* A sorgo or sweet sorghum not identical with any known variety: possibly a hybrid between *Amber* and *Orange*—at any rate related to *Amber.*" (*Ball.*)

22788 to 22790. MEDICAGO SATIVA L. **Alfalfa.**

From Tashkend, Turkestan. Purchased from Mr. H. W. Duerrschmidt. Received May 4, 1908.

Turkestan.

22788. From the district of Aulieata, severe winter, average summer.

22789. From Tschimkent, average summer, not cold winter.

22790. From Khiva, hot summer, mild winter.

22791 to 22793.

From Manila, P. I. Presented by Mr. H. N. Whitford, chief, Division of Forest Investigations, Bureau of Forestry, Department of the Interior. Received May 4, 1908.

22791. CHRYSOPHYLLUM sp. (?)

"This is a rare species, growing in the forests, with a fruit about the size of a Japanese persimmon. It has a slightly agreeable taste." (*Whitford.*)

22792. STERCULIA FOETIDA L.

"*Calumpang.* An oil is made from these seeds." (*Whitford.*) (For further description see No. 17139.)

22793. PITHECOLOBIUM ACLE (Blanco) Vidal.

"*Acle* is one of our valuable timber trees. In quality it is the nearest wood we have to walnut." (*Whitford.*)

22794 to 22796.

From Saigon, Cochin China. Presented by Mr. J. E. Conner, American consul. Received May 4, 1908.

22794. IRVINGIA OLIVERI Pierre.

22795. ANONA SQUAMOSA L. (For description see No. 9024.)

22796. ANONA RETICULATA L. (For description see No. 5210.)

22797 to 22809.

From Chihuahua, Mexico. Presented by Dr. Edward Palmer. Received May 2, 1908.

22797 to 22809—Continued.

The following seeds, with Mexican names:

22797 to 22802. PHASEOLUS COCCINEUS L. **Scarlet runner.**

"*Frijol patol.* There are six different colored beans under this name. Cultivation may reveal some new novelties and it may prove a fine ornamental; it is much grown here to run over arbors. The green pods are eaten." (*Palmer.*)

22797. White.

22798. Black.

22799. Lavender, mottled with black.

22800. Mauve, mottled with lavender.

22801. Mauve, mottled with black.

22802. Black, mottled with mauve and gray.

22803. CAPSICUM FRUTESCENS L. **Pepper.**

"*Chile quipin.* From the mountains. It is locally much used, especially in vinegar." (*Palmer.*)

22804 to 22809. CAPSICUM ANNUUM L. **Pepper.**

22804. "*Chile tapatio.*" Cultivated in Guadalajara, Jalisco, Mexico.

22805. "*Chile negro.*" Cultivated in Julimez, Chihuahua, Mexico.

22806. "*Chile mirosoc.*" Cultivated in Aguascalientes, Mexico.

22807. "*Chile colorado.*" Cultivated in Chihuahua City, Mexico.

22808. "*Chile bolito.*" Cultivated in Sta. Rosalia, Chihuahua, Mexico.

22809. "*Chile pasilla.*" Cultivated in San Pablo and Meoqui, Chihuahua, Mexico.

22810. CUCURBITA PEPO L. **Pumpkin.**

From Jerusalem, Palestine. Presented by Mr. John E. Dinsmore, American Colony, through Mr. Thomas R. Wallace, American consul. Received April 29, 1908.

"The Arabic name is *Kusa.* It is probably a variety of vegetable marrow and is prepared for food in several ways: It may be boiled, fried, stewed, baked, etc. The most common way of cooking it in the Orient is to scoop out the inside and to stuff it with rice, meat, and butter, which is highly seasoned, and then boil it until well done.

"Plant the seeds in hills 2 inches deep, two or three in each hill, in a very light, well-worked loam. Until the plants appear above ground, care must be taken that the ground does not become caked, as otherwise the plants will be destroyed. In Palestine they grow without any rain whatsoever, but there are heavy dews." (*Dinsmore.*)

22811 to 22818.

From Saigon, Cochin China. Presented by Mr. J. E. Conner, American consul. Received May 6, 1908.

The following tubers:

22811. CALADIUM BICOLOR (Ait.) Vent.

22812. AMORPHOPHALLUS CAMPANULATUS (Roxb.) Blume.

22811 to 22818—Continued.

22813. PINELLIA COCHINCHINENSE (Blume) W. F. Wight. (ARISAEMA COCHINCHINENSE Blume.)

22814. COLOCASIA INDICA (Lour.) Kunth.

22815. XANTHOSOMA SAGITTAEFOLIUM (L.) Schott.

22816. ALOCASIA MACRORRHIZA (L.) Schott.

22817. ARUM sp. (?)

22818. COLOCASIA ESCULENTA (L.) Schott.

"As many as seven species of the Colocasia are found native in Cochin China, two of which are edible. Of these two, the *Colocasia indica* and the *Colocasia esculenta*, known to the natives as *Khoia mon sen* and *Khoia mon sap*, respectively, the latter, which is by far the best species for food as well as in yield, includes two additional varieties, known as *Mon ding* and *Mon mink tia.*

"In addition to these edible species, there are as many as four ornamental varieties, and one, the *Pinellia cochinchinense*, is a medicinal herb; all flourish in a wild state.

"The cultivation of the edible species should begin in March or April. They require a marshy soil and are planted in ridges like sweet potatoes, about 30 cm. apart, with about twice that space between the ridges. Young offshoots from the bottom of the plants are also used for plant propagation, and the time necessary to mature is six months.

"The tubers are eaten boiled, the same as the sweet potato, and a kind of flour is also made from them. The price of a picul of 60 kilograms is 1 piaster 80—less than 7 cents per pound." (*Conner.*)

22819. DENDROCALAMUS STRICTUS (Roxb.) Nees. **Bamboo.**

From India. Presented by Mr. Jean Houzeau de Lehaie, Saint Symphorien, Belgium, through Lady Brandis, 21 Kaiserstrasse, Bonn, Germany. Received May 6, 1908.

See S. P. I. No. 21548 for description.

22820 to 22824. ANDROPOGON SORGHUM (L.) Brot.

From Entebbe, Uganda. Presented by Mr. M. T. Dawe, officer in charge, Botanical, Forestry, and Scientific Department. Received April 6, 1908.

Seed of the following sorghums; varietal descriptions by Mr. Carleton R. Ball:

22820.

Apparently a sweet sorghum from discoloration of pith; seed and glumes similar in shape and size to *Sumac* sorgo, but branches longer and spreading. Seeds remarkably small.

22821.

Similar to No. 22820; pith also discolored; head much longer; seeds larger.

22822.

Large head; long spreading branches; glumes short, black, shining; seeds flattened, somewhat pointed at tip, orange-red or paler to nearly dirty white.

22823.

Similar to No. 22822, but head and branches smaller; seeds dirty white or with pinkish tinge.

22820 to 22824—Continued.

22824.

Similar to No. 22823, but branches heavier; head more compact; seeds nearly white.

All except No. 22820 are closely related in general character, varying chiefly in color of seed and size of head. The first differs by much smaller and blunter seeds.

22825. ULMUS PUMILA L. **Elm.**

From Fengtai, near Peking, Chihli, China. Received through Mr. Frank N. Meyer, agricultural explorer, May 9, 1908.

"(No. 664, Mar. 26, 1908.) Var. *pendula*. A new form of a weeping elm; said to be the only tree of its kind in existence. Growing on a grave at Fengtai. Well fit as a cemetery tree in the semiarid regions of the United States. Chinese name *Lung tsao yu shu*, meaning dragon's claw elm, on account of the rather gnarled branches." (*Meyer.*)

22826. CITRUS AURANTIUM SINENSIS L. **Sweet orange.**

From Kabylia, Algeria. Presented by Dr. L. Trabut, government botanist, Algiers, Algeria. Received May 11, 1908.

"Garden orange. Matures last of April to May. Fruit very sweet." (*Trabut.*)

22827. CACARA EROSA (L.) Kuntze.

From Porto Rico. Presented by Mr. William Allan, 136 W. 79th street, New York, through Mr. C. V. Piper. Received May 11, 1908.

"Beans found growing wild over our place in Porto Rico; the pods are more the shape of cowpeas, but not over 4 inches long, and contain a brown bean. The plant is bushy, standing about 18 to 24 inches high. It does not run and seems to make only one growth per year; it has a large, bulbous root, similar to a ruta-baga turnip, some of them I have seen plowed up measuring 6 to 8 inches in diameter; very starchy when cut open." (*Allan.*) (For further description see S. P. I. No. 22971.)

22828 to 22832. DIOSCOREA spp. **Yam.**

From Sibpur, Calcutta, India. Presented by Mr. W. W. Smith, officiating superintendent, Royal Botanic Garden, through Mr. O. W. Barrett. Received May 11, 1908.

The following tubers, vernacular names in italic:

22828. DIOSCOREA ALATA L.

Kham alu.

22829. DIOSCOREA RUBELLA Roxb.

Guraniya alu.

22830. DIOSCOREA PURPUREA Roxb.

Rakto guraniya alu.

22831. DIOSCOREA FASCICULATA Roxb.

Susni alu.

"The above are cultivated generally, and edible when cooked." (*Smith.*)

22832. DIOSCOREA ANGUINA Roxb.

Kukur alu.

"This variety is wild; not eaten." (*Smith.*)

22833. PANICUM MAXIMUM Jacq.

From Pretoria, Transvaal, South Africa. Presented by Mr. J. Burtt Davy, government agrostologist and botanist, Transvaal Department of Agriculture. Received May 11, 1908.

"*Bush-Buffel* grass, one of our best perennial pasture and hay grasses. In the 'Flora Capensis,' Stapf refers this to *Panicum maximum*, but cultivated side by side with the latter for several years at my experiment station it shows marked and constant differences; these may not prove to be other than varietal, but are sufficient for cultural purposes. Our Buffel grass is finer in texture than Guinea grass and is not so tropical in its requirements. It is found in very dry country at an altitude of about 2,500 to 2,600 feet; it is somewhat sensitive to frost, the tops dying but the roots not being killed in winter. It may prove a useful grass on light soils in the Southern States and is worth trial also in Arizona and southern California. This is the principal feed of stock which trek down to the 'Winter's veld' in winter, and it is said to have great fattening properties even when dry. Seed does not ripen evenly." (*Davy.*)

22834. MEDICAGO SATIVA L. **Alfalfa.**

From near San Pedro, near Pacasmayo, Peru. Purchased in Peru by Wessel, Duval & Co., New York, N. Y. Secured from them by Mr. C. J. Brand. Received May 12, 1908.

Andean. "This alfalfa was secured through the same firm as was the Peruvian alfalfa, S. P. I. No. 9303, described in Bulletin 118, Bureau of Plant Industry." (*Brand.*)

"The parties in Peru who secured the seed state: 'The price to-day (June 9) is about 75 soles per 100 pounds Spanish, on board, Pacasmayo, packed in double bags. San Pedro seed is considered the best on the coast, but in our opinion that harvested in other parts of the province is just as good.

"'Alfalfa is generally sown (when there is water) in the months of June to September (the winter months), when the pasture grows highest, for in the summer months the alfalfa does not flourish and remains small. In general, the alfalfa fields last for four or more years, being cut down every 45 days. Alfalfa is sown in all kinds of earth, except in that containing saltpeter, which kills the plant. (Loose, sandy soil with moist subsoil is the best.)

"'As to harvesting the seed, this is uncertain. Very often the alfalfa fields flower in the best way, but with one or two nights of low temperature, all the flowers fall off and consequently the harvest of seed is bad. It is not possible to state the quantity of seed which can be gathered in this province in one year, for this depends on the abundance of alfalfa and the number of fields which are left for seed. The older the alfalfa fields the better seed they yield. During this year many of the fields which were left for seed have failed, for the reasons given above; still we consider that about 2,000 quintals of seed will have been gathered.'" (*Wessel, Duval & Co.*)

22835 to 22860. PHOENIX DACTYLIFERA L. **Date.**

From the Persian Gulf region. Received through Mr. William C. Magelssen, American consul, Bagdad, Turkey, May 14, 1908.

22835. *Maktum* (Asfar).

22836. *Maktum* (Ahmar).

22837. *Aschcrasi.*

22838. *Khastawi.*

22839. *Halawi.*

22840. *Khadrawi.*

22835 to 22860—Continued.

22841. *Sukcri.*
22842. *Shukker Modabel.*
22843. *Barban.*
22844. *Beneffshi.*
22845. *Hussein Effendi.*
22846. *Taberzel*
22847. *Zehdi.*
22848. *Maiah.*
22849. *Jozi.*
22850. *Shukker.*
22851. *Shitwi Asfar.*
22852. *Duggal* (Omkom-el Ahmar).
22853. *Duggal* (Sultani).
22854. *Duggal* (Shomaieh).
22855. *Duggal* (Hilwa).
22856. *Ascherasi* (Male).
22857. *Khastawi* (Male).
22858. *Barban* (Male).
22859. *Zehdi* (Male).
22860. *Khadrawi* (Male).

22861 to 22873.

From Peking, Chihli, China. Received through Mr. Frank N. Meyer, agricultural explorer, at the Plant Introduction Garden, Chico, Cal., May 4, 1908.

The following seeds and cuttings:

22861. Populus sp. **Poplar.**

From Wutaishan, Shansi, China. "(No. 260, Feb. 27, 1908.) A white-barked poplar, standing apparently between *P. alba tomentosa* (Carr.) Wesm. and *P. balsamifera suaveolens* (Fisch.) Wesm. Growing at 5,000 to 8,000 feet elevation. Used extensively for sand and stone binding, and planted at the mouth of ravines so as to prevent the mountain torrents carrying their débris into the cultivated lands of the valleys. Of use to us for the same purpose, and as a cheerful avenue tree for winter effects. Chinese name *Ching yang shu*, meaning green poplar, on account of the bark being very green as long as the tree is young." (*Meyer.*)

22862. (Undetermined.)

From Tchailingtse Temple, Wutaishan, Shansi, China. "(No. 265, Feb. 25, 1908.) A shrub resembling a Lonicera, but spiny on the young shoots and of a very open growth. Found in shady, sandy spots in a larch forest at about 8,000 feet elevation. Chinese name *Tcheng pee.*" (*Meyer.*)

22863. Philadelphus sp. (?)

From Tchailingtse Temple, Wutaishan, Shansi, China. "(No. 266, Feb. 25, 1908.) A low shrub growing in open places in a larch forest at about 8,000 feet elevation. Chinese name *Lu tao mo.*" (*Meyer.*)

22864. Hydrangea sp.

From Tchenghaitse Temple, Wutaishan, Shansi, China. "(No. 267, Feb. 27, 1908.) Probably *Hydrangea vestita pubescens* Maxim.; found growing in dense shade, as the borders of a pine-tree plantation. Apparently the same as No. 187 (S. P. I. No. 21925). Chinese name *Mar pa tse.*" (*Meyer.*)

22865. Viburnum sp.

From Tchenghaitse Temple, Wutaishan, Shansi, China. "(No. 268, Feb. 27, 1908.) Found growing in thickets on mountain slopes at high altitudes." (*Meyer.*)

22861 to 22873—Continued.

22866. (Undetermined.) **Sedge.**

From near Taichou, Shansi, China. "(No. 279, Mar. 2, 1908.) A sedge growing on strongly alkaline lands of a light sandy nature. Seems to be able to stand any amount of drought." (*Meyer.*)

22867. TAMARIX sp.

From near Taiyuanfu, Shansi, China. "(No. 287, Mar. 9, 1908.) A Tamarix growing on sandy and strongly alkaline soils; might be utilized in the alkaline sections of the western United States. Mostly seen as a low shrub, but when left alone grows up into a small tree. The twigs are used for basket making and for fuel. Chinese name *Shan cheng liu.*" (*Meyer.*)

22868. FUNKIA sp.

From Tsingyuenhsien, Shansi, China. "(No. 662, Mar. 12, 1908.) This plant is said to bear large, white, fragrant flowers. Has to be kept indoors in winter time. Chinese name *Pai yu tcheng hua.*" (*Meyer.*)

22869. PAEONIA ALBIFLORA Pall. **Peony.**

From Bimoyen Temple, mountains west of Peking, Chihli, China. "(No. 663, Mar. 18, 1908.) A very fine, white, double-flowered, fragrant peony (herbaceous). Chinese name *Pai shoo yoo hua.*" (*Meyer.*)

22870. GLYCYRRHIZA GLABRA L. **Licorice.**

From near Mapootoo, Hsintchan District, Shansi, China. "(No. 939a, Mar. 8, 1908.) Found growing along dry and exposed ridges." (*Meyer.*)

22871. EUONYMUS sp.

From near Tongchangdi, Kwohsien District, Shansi, China. "(No. 940a, Mar. 5, 1908.) Seeds picked up from the ground in a loess gorge, where the small shrubs themselves were in unapproachable situations." (*Meyer.*)

22872. EUONYMUS sp.

From Taiyuanfu, Shansi, China. "(No. 941a, Mar. 13, 1908.) A shrubby Euonymus, semideciduous, bearing many white capsules, out of which the scarlet seeds peep. Is grown sparsely by the Chinese as a pot plant for winter table decoration. Local name *Shi yüe mae.*" (*Meyer.*)

22873. RHAMNUS sp.

From mountains near Tsintse, Shansi, China. "(No. 942a, Mar. 9, 1908.) A very dwarfy Rhamnus, found growing on dry, exposed mountain slopes. Well fit for rockery purposes." (*Meyer.*)

22874 to 22885. GLYCINE HISPIDA (Moench) Maxim. Soy bean.

From Tokyo, Japan. Purchased from the Tokyo Plant, Seed, and Implement Company. Received May 14, 1908.

The following seeds, varietal identifications and descriptions made by Mr. H. T. Nielsen:

22874. Green.

22875. *Flat King.* Same as Nos. 19982 and 17252.

22876. Yellow. Similar in appearance to *Hollybrook*, No. 17269.

22877. *Okute.* Apparently identical with No. 19986.

22878. *Butterball.* Apparently identical with Nos. 19981 and 17273.

22874 to 22885—Continued.

22879. Yellow. Evidently two varieties; most of the seed very similar in appearance to *Acme*, No. 14954.

22880. Yellow. Quite closely resembling *Hollybrook*.

22881. Green.

22882. Yellow. Apparently identical with No. 20892.

22883. *Buckshot*. Apparently identical with No. 19987.

22884. Yellow, with a slight purple marking on many of the seeds.

22885. *Amherst*. Apparently identical with Nos. 19983 and 17275.

22886 to 22888.

From Swatow, Kwangtung, China. Presented by Mr. William Ashmore, jr., through Rev. J. M. W. Farnham, Chinese Tract Society, Shanghai, China. Received May 14, 1908.

The following seeds, varietal descriptions by Mr. H. T. Nielsen:

22886. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

Black.

22887. VIGNA SESQUIPEDALIS (L.) W. F. Wight.

Red with one end and half of keel white.

22888. VIGNA CATJANG (Burm.) Walp.

Similar in appearance to *Chinese Red*, Nos. 17328 and 22635, but seeds are smaller.

22891 to 22895.

From Bridgetown, Barbados, British West Indies. Presented by Mr. John R. Bovell, superintendent, Agricultural Department, at the request of the Imperial Commissioner of Agriculture for the West Indies. Received May 13, 1908.

The following tubers:

22891. COLOCASIA sp. **Taro.**

Japanese taro.

22892. COLOCASIA sp. **Taro.**

Malanga (via) Cuba.

22893. COLOCASIA sp. **Taro.**

Trinidad Yellow.

22894. COLOCASIA sp.

Dasheen.

22895. XANTHOSOMA sp. **Yautia.**

Amarilla.

For previous shipment and remarks, see Nos. 22513 to 22523.

22896. (Undetermined.)

From southern Brazil. Presented by Mr. H. Nehrling, Gotha, Fla., through Mr. R. A. Young. Received May 18, 1908.

"A new root crop from southern Brazil, where it is called *Mangaridas*. The tubers look much like Caladium tubers, but the foliage differs from that genus. It is undoubtedly an aroid, but what it may be I do not know. It is cultivated largely in southern Brazil for its edible tubers. It is certainly no *Xanthosoma*, and it is no *Colocasia*." (*Nehrling.*)

22897 to 22903.

From Paotingfu, Chihli, China. Presented by Rev. J. W. Lowrie, D. D., through Rev. J. M. W. Farnham, Chinese Tract Society, Shanghai, China. Received April 22, 1908.

The following seeds. Chinese names in italic as given by Mr. Lowrie. Descriptions of varieties by Mr. H. T. Nielsen.

22897 to 22901. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

22897. *Da ching don.*

Green. Similar to No. 17857.

22898. *Hwang don.*

Yellow.

22899. "*Hei don.* Boiled as a fodder for mules and horses. Oil expressed from it, and refuse used as manure." (*Lowrie.*)

Black. Similar to *Cloud*, No. 16790.

22900. "*Da wu don.* Tends to vary after successive plantings." (*Lowrie.*)

Black. Similar in appearance to *Nuttall*, Nos. 17253 and 19183, but has green cotyledons.

22901. *Hsiao bai hei don.*

Smoky yellow.

22902. VIGNA SESQUIPEDALIS (L.) W. F. Wight.

Tsai don.
Red.

22903. VIGNA UNGUICULATA (L.) Walp. **Cowpea.**

Giang don.

Mottled. Similar in appearance to Nos. 17339 and 18617.

22904 to 22906.

From Shanghai, Kiangsu, China. Received through Mr. Frank N. Meyer, agricultural explorer, at the Plant Introduction Garden, Chico, Cal., August, 1907.

The following seeds:

22904. MYRICA NAGI Thunb.

From Dongsi, Chehkiang, China. "(No. 732a, June 25, 1907.) Large-fruited variety, called by foreigners the 'strawberry tree,' by the Chinese *Yang mae.* A small evergreen tree or large shrub, bearing round, wine red colored fruits which are very pleasing to the taste and can be eaten fresh, stewed, or preserved in spirits. The Chinese say the tree can not bear transplanting, so confine their roots by sowing them one or two seeds in each pot." (*Meyer.*)

22905. MYRICA NAGI Thunb.

From Dongsi, Chehkiang, China. "(No. 733a, June 25, 1907.) Medium-sized fruits. For further information see preceding number (S. P. I. No. 22904). Besides being a very agreeable fruit, the tree is also decidedly ornamental, especially when loaded with its carminic fruits. Loves, apparently, sheltered, well-drained locations." (*Meyer.*)

22904 to 22906—Continued.

22906. Myrica nagi Thunb.

From Dongsi, Chehkiang, China. "(No. 734a, June 25, 1907.) Small-fruited variety. For further remarks, see Nos. 732a and 733a (S. P. I. Nos. 22904 and 22905). The Chinese graft the large, sweet-fruited varieties upon the wild seedlings, but even among the seedlings there is a large variation in size of fruits and in productiveness." (*Meyer.*)

For previous importations see S. P. I. Nos. 9164 and 9314.

22907. Carex triangularis Boeckler. **Sedge.**

From Texas. Collected by Mr. F. W. Clarke, special agent in charge of matting-rush investigations. Received May, 1908.

"This seed was collected from plants growing in ditches and marshy places along and back from the Victoria division of the S. P. R. R. between Wharton and El Campo, Tex. No seed was gathered from a stalk less than 3 feet tall, and most of the seed was secured from plants 3 feet 6 inches high and upwards. This Carex occurs in abundant quantities from Crowley, La., to Victoria, Tex., and I presume it covers the whole coast country, but it is probably most plentiful in the black, waxy rice belt of Texas." (*Clarke.*) (For previous introduction see S. P. I. No. 20990.)

22908. Lens esculenta Moench.

From Mexico. Secured by Mr. David Griffiths, assistant agriculturist, United States Department of Agriculture, on the market at Laredo, Tex. Received May 6, 1908.

"*Lanteja.* A common leguminous plant grown in Mexico extensively and used in about the same way as the chick pea." (*Griffiths.*)

22909. Picea obovata schrenkiana (Fisch. & Mey.) Masters.

From St. Petersburg, Russia. Presented by Dr. A. Fischer von Waldheim, Imperial Botanic Gardens. Received March 27, 1908.

Tall, pyramidal tree, with pendulous branchlets and dull green leaves. Native of central Asia. (*Extract from Bailey.*)

22910. Xanthosoma sp. **Yautia.**

From Barbados, British West Indies. Presented by Mr. Valpierre Croney, 9 East 97th street, New York, through Mr. O. W. Barrett. Received May 11, 1908.

Nut Eddo.

22911 to 22913. Andropogon sorghum (L.) Brot.

From Tsungming Island, China. Obtained through Rev. J. Ware and presented by Mr. S. P. Barchet, interpreter, American consulate, Shanghai, China. Received May 20, 1908:

22911. **Kowliang.**

Brown.

22912. **Kowliang.**

Black-Hull.

22911 to 22913—Continued.

22913. **Sorgo.**

Chinese.

"The white variety (S. P. I. No. 22912) is considered inferior to the red (S. P. I. No. 22911, *Brown*), though planted in the same way. It is planted in richly manured land, in rows 6 inches wide covered lightly with half an inch of earth. If plants come up too thick or crowded, the plants which should be removed are not pulled, but cut off with a sharp knife, so as not to disturb the roots of neighboring plants." (*Barchet.*)

22914 and 22915.

From Shanghai, Kiangsu, China. Received through Mr. Frank N. Meyer, agricultural explorer, May 19, 1908.

22914. ZIZYPHUS SATIVA Gaertn. **Chinese date.**

From Tientsin, Chihli, China. "(No. 667, Apr. 6, 1908.) Variety *tortuosa*. The *Crooked* or *Dragon's Claw* Chinese date. Cuttings of a very peculiar variety of the Chinese date, making a quaint and real Chinese impression. A rare plant, and very expensive in China. Chinese name *Lung tsao tsao shu*. Said to be very difficult to graft." (*Meyer.*)

22915. CASTANOPSIS TIBETANA Hance. **Chestnut.**

From Shanghai, Kiangsu, China. "(No. 959a, Apr. 14, 1908.) A very large leaved, evergreen chestnut, growing into a stately, ornamental tree bearing edible nuts. Very rare in China. Obtained through Bishop G. E. Moule, of Hangchow. These trees will grow in the localities where oranges thrive." (*Meyer.*)

22916 to 22918.

From Gyangze, Tibet. Procured from the British trade agent at Gyangze and presented by Dr. Robert T. Morris, 616 Madison avenue, New York, through Mr. O. W. Barrett. Received May 19, 1908.

22916. TRITICUM AESTIVUM L. **Wheat.**

22917. HORDEUM DISTICHON NUDUM L. **Barley.**

22918. PISUM ARVENSE L. **Field pea.**

"I would not presume to venture any opinion about the value of these seeds, but they grow in very high mountain regions and must at least be hardy in trying climates." (*Morris.*)

22919 to 22922. GLYCINE HISPIDA (Moench) Maxim. Soy bean.

From Ingchung, via Fuchau, China. Presented by Mr. J. Willis Hawley. Received May 22, 1908.

The following seeds. Varietal descriptions by Mr. H. T. Nielsen:

22919. Black. Very similar to No. 22886.

22920. Yellowish green.

22921. Yellow. Very similar to No. 22714.

22922. Yellow. Seed resembles *Mammoth* very closely, but slightly smaller.

22923. STIZOLOBIUM sp. **Velvet bean.**[a]

From Pensacola, Fla. Presented by Mr. P. K. Yonge, through Prof. S. M. Tracy, Biloxi, Miss. Received May 23, 1908.

White.

22924 and 22925.

From Italy. Presented by Dr. Robert T. Morris, 616 Madison avenue, New York, through Mr. O. W. Barrett. Received May 22, 1908.

22924. LAGENARIA VULGARIS Ser. **Gourd.**

"*Zucctuni.* Similar to *Zucchette* (S. P. I. No. 22925), but having smaller fruits." (*Morris.*)

22925. CUCURBITA PEPO L. **Pumpkin.**

"*Zucchette.* Climbing vine; very long fruit; used like cucumber, sliced and in salads; also boiled like turnip, and may be stuffed with meat and boiled or fried." (*Morris.*)

22926. ZINZIBER OFFICINALE Rosc. **Ginger.**

From Kingston, Jamaica. Presented by Mr. W. Harris, superintendent, Department of Agriculture, Hope Gardens, at the request of Dr. R. H. True. Received May 29, 1908.

Procured for Dr. R. H. True's experiments at the Drug Plant Garden, Orange City, Fla.

22927. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Shanghai, Kiangsu, China. Presented by Rev. J. M. W. Farnham, Chinese Tract Society. Received May 27, 1908.

Black. "Identical with *Shanghai*, No. 14952; cotyledons are green." (*Nielsen.*)

22928. CUCURBITA MAXIMA Duch. **Venetian squash.**

From Milan, Italy. Purchased from Fratelli Ingegnoli. Received May 28, 1908.

"*Zucca marina.* Sow in April in ground well manured and watered, making the holes distant from each other 50 centimeters; fill each one with good soil mixed with manure in which place two or three seeds and press down the earth. When the plants have developed, leave the more robust ones. Nourish and water abundantly with water mixed with liquid manure.

"To have large fruit leave only two or three fruits on each plant and remove the superfluous branches." (*Fratelli Ingegnoli.*)

22929 to 22933. VIGNA UNGUICULATA (L.) Walp. **Cowpea.**

From Mount Silinda, Melsetter District, Rhodesia, South Africa. Presented by Rev. Columbus C. Fuller. Received May 18 and 23, 1908.

The following seeds, descriptions of varieties by Mr. H. T. Nielsen:

22929. Similar in appearance to *Unknown*, but has a slight purplish tinge.

22930. Similar in appearance to *Macassar*, Nos. 21006 and 21299.

22931. Similar in appearance to *New Era*, but seed is a trifle smaller.

22929 to 22933—Continued.

22932. Black. Similar to our common black varieties, but seed a trifle smaller and many of them marked with small, gray specks.

22933. Similar in appearance to *Taylor*, No. 17342, but not quite so large.

"The smaller varieties are best for our rather poor soil." (*Fuller.*)

22934. DOLICHOS LABLAB L.

From Karlsruhe, Germany. Presented by Prof. L. Graebener, director, Botanical Gardens. Received May 28, 1908.

22935 and 22936.

From Tekhôe, via Fuchau, Fuhkein, China. Presented by Miss Jessie Alice Marriott. Received June 1, 1908.

22935. VIGNA SESQUIPEDALIS (L.) W. F. Wight.

22936. PISUM ARVENSE L. **Field pea.**

22937. FICUS sp.

From Mokanshan, Chehkiang, China. Received through Mr. Frank N. Meyer, agricultural explorer, June 2, 1908.

"(No. 668, Apr. 22, 1908.) An ornamental creeping Ficus covering here and there rocks, bowlders, and tree trunks. Of use as a covering vine in the mild, moist-wintered regions of the United States. Closely allied to the well-known *Ficus repens.*" (*Meyer.*)

22938. VIGNA UNGUICULATA (L.) Walp. **Cowpea.**

From Pará, Brazil. Presented by Mr. C. F. Baker, Museu Goeldi. Received June 1, 1908.

"*Feijaõ manteiga.* One of the highest priced beans in the Pará market. Would make one of the very best soiling crops for this region." (*Baker.*)

"One of the *Lady* peas, probably *Conch.*" (*Nielsen.*)

22939. CITRUS AURANTIUM SINENSIS L. **Sweet orange.**

From Pará, Brazil. Presented by Mr. C. F. Baker, Museu Goeldi. Received June 1, 1908.

"One of the largest, finest oranges grown at Pará." (*Baker.*)

22940. MEDICAGO SATIVA L. **Alfalfa.**

From Lima, Peru. Received from E. Sayan Palacios & Co., through Mr. C. J. Brand, May 20, 1908.

"This is a distinct Peruvian type of alfalfa as distinguished from the Chilean." (*Palacios.*)

"This will no doubt prove to be very similar to, if not identical with, S. P. I. No. 9303." (*Brand.*)

22941. SAGUERUS PINNATUS Wurmb. **Sugar palm.**

From Buitenzorg, Java. Presented by Dr. M. Treub, director, Department of Agriculture. Received June 4, 1908.

"In Java the *Arenga saccharifera* (*Saguerus pinnatus*) is not cultivated in regular plantations; it needs much room and light and may be planted at

22941—Continued.

distances of 15 to 18 feet; the planting holes have to be 2 to 3 feet in breadth and in depth. At an altitude of 3,000 feet above sea level the tree is fit to be tapped at an age of about 16 years. It yields more at an altitude of 1,800 feet, where it fruits after 12 or 13 years. In the lowlands, too, it will succeed, but I can not say when it fruits there.

"The *aren idjo* (green arenga) is considered to be the most productive variety of our country. In the high regions it produces during about four years, in lower parts during three years; the quantity of juice and sugar continue getting less as the tree grows older. At the first tapping—this means when the first male peduncle is tapped—the tree produces about 7 liters of juice per twenty-four hours during about two and one-half months. Of some trees a second peduncle may be tapped immediately after the first one; of others, only after some time (three months). An arenga tree may be tapped from three to ten times, with an average of six times. At the second and following tappings the arenga produces at every tapping for a period of about forty-five days about 5½ liters of juice (per twenty-four hours) of a declining sugar content; about 3½ liters of juice of the first tapping give about 0.617 kilo of sugar; the following tappings give the same quantity of sugar to a production of 5½ liters of juice. The production of sugar of one tree during its whole lease of life may be stated at about 225 kilos, with a local value of 13 cents (about 5 American cents) per kilo, or in total about 30 Dutch guilders (12 American dollars).

"The sugar is prepared by boiling the juice. This boiling takes much fuel, which fact gives no trouble in the interior of Java; however, if wood had to be bought for the purpose—as it would be in towns of Java—the value of the sugar would not make good the expenses for fuel. Sugar, therefore, is not manufactured in and near the towns.

"As to the method of tapping, I beg to refer to the work of A. Tschirch, Indische Heil und Nutzpflansen, Berlin, 1892, page 160. This book does not mention that the male peduncle has to be swung to and fro during some days, and afterwards beaten effectively before the inflorescence is cut off; further, that every day during the tapping a slice of the peduncle has to be cut off. Experiments made here some years ago by Professor Molisch have shown that without any doubt stimuli have a great effect on the flow of sugar-containing juice.

"Taking the figures given above as a basis for calculation, an acre can be planted with 160 trees of *A. saccharifera* (*S. pinnatus*), which, producing 500 pounds of sugar per tree, will theoretically give a total production of 80,000 pounds, equal to 35 tons per acre, at the end of from fifteen to twenty years, or an average of from 2 to 2¾ tons per year.

"Personally, I am inclined to think the actual production will be considerably below these figures, one reason for this being that with such close planting the trees will not be able to develop fully; probably an average of about 100 fully developed producing trees will be nearer the mark, but even then a production of over 1 ton per year will be obtained.

"The great drawback is that, from the nature of the sugar palm, it will probably not be possible to grow catch crops after the third or fourth year; during the first twelve to sixteen years no profits are obtained; then comes a big harvest during three or four years, after which the plantation is valueless, and it will entail considerable expense to again clear the land for other crops. Moreover, taking into consideration that most people, and especially tropical people, are not inclined to wait a dozen years or longer before they get any

22941—Continued.

return for their labor, I should not consider it advisable to make regular plantations of *A. saccharifera* (*S. pinnatus*). Quite a different matter is to plant the tree in village gardens along roads, alternating with the shade trees. In such locations, under which the labor of planting and cultivating is next to nothing, the people of Porto Rico can afford to wait for the returns, which will probably prove quite remunerative." (*Treub.*)

22942 to 22944.

From Uitenhage, Cape Colony, South Africa. Presented by Mr. H. Fairey, Public Park and Gardens. Received June 4, 1908.

22942. ANDROPOGON SORGHUM (L.) Brot. **Sorgo.**

"This sorgo has pyramidal spreading panicles similar to *Amber*, but with larger spikelets and seed." (*Ball.*)

22943. PENNISETUM AMERICANUM (L.) Schum. **Pearl millet.**

"This seed is from Rhodesia, South Africa, and is known as *Myouti* by the Mashona natives (pronounced something like Meout). The seed is much used, I am told, for poultry feeding, and an oil can also be extracted from it." (*Fairey.*)

22944. (Undetermined.)

"A legume of no economic value so far as I know, but is useful for edgings to walks and beds in this country, but would not withstand your winters." (*Fairey.*)

22945. PHASEOLUS sp. **Bean.**

From Java. Presented by Mr. P. D. Mulder, Banda-Neira, Molukken Islands, East Indies. Received June 4, 1908.

"*Kratok.* The seeds when young are used by the natives for food. When the beans are older they are exported. In Java it is planted for making the bottom lands more fertile, and much profit is derived from it." (*Mulder.*)

22946. MEDICAGO SATIVA L. **Alfalfa.**

From Mitchell, S. Dak. Grown by Prof. W. A. Wheeler. Received through Mr. C. J. Brand, June 3, 1908.

"(P. L. H. No. 3332.) The so-called Baltic alfalfa, grown from South Dakota Agricultural Experiment Station No. 167. The original source of the seed is unknown, the parent seed having been purchased in 1896 from a seed dealer at Hartford, S. Dak. This is a very free seeding variety and is unusually hardy." (*Brand.*)

22947. MEDICAGO SATIVA L. **Alfalfa.**

From Excelsior, Minn. Secured by Mr. C. J. Brand from Prof. W. A. Wheeler, Mitchell, S. Dak., and was probably grown by Mr. A. B. Lyman, of Excelsior, Minn., from whom Professor Wheeler purchased it. Received June 3, 1908.

Grimm. (P. L. H. No. 3333.)

22948. MEDICAGO SATIVA L. **Alfalfa.**

From Guaranda, Ecuador. Received from Mr. H. R. Dietrich, consul-general, Guayaquil, Ecuador, through Mr. C. J. Brand, June 8, 1908.

"(P. L. H. No. 3326.) A rapid-growing form of alfalfa from the Andean plateau, similar in many respects to the Peruvian alfalfa described in Bulletin No. 118, Bureau of Plant Industry." (*Brand.*)

22949. MEDICAGO SATIVA L. **Alfalfa.**

From Chile, South America. Presented by Mr. José D. Husbands, Limávida, Chile, through Mr. C. V. Piper. Received June 3, 1908.

"Wild alfalfa found in the foothills of the Cordillera, in a section of moist, virgin land, upon which the alfalfa appears as a weed when field crops are planted for the first time." (*Husbands.*)

22955. GARCINIA BINUCAO (Blanco) Choisy.

From Manila, P. I. Presented by Mr. W. S. Lyon. Received June 11, 1908.

"This has the widest range of any species (of Garcinia) which I know; its fruiting season covers the longest time (March to July); it is fairly robust, sometimes 40 meters high, and is the most cosmopolitan of any species we have. I have seen it at sea level and up to 3,000 feet. This *binucao*, or *camangis*, or *gatasan*, et al. is found in rock fissures; in dry, gravelly, sterile washes; on the margins of swamps, and in rich, fat valley soils." (*Lyon.*)

22956. ANONA RETICULATA L. **Custard apple.**

From Port of Spain, Trinidad, British West Indies. Presented by Dr. E. André. Received June 10, 1908.

22957. BELOU MARMELOS (L.) W. F. Wight. (AEGLE MARMELOS (L.) Correa.) **Bael tree.**

From Nyaunglebin, Burma, India. Presented by Rev. Henry W. Hale, Box 30, R. F. D. No. 1, Savannah, Ga. Received June 8, 1908.

"These seeds are from the very best bael fruit." (*Hale.*)

"The bael tree of India ascends to an altitude of 4,000 feet. It grows to a height of 40 feet. The fruit has matured near Rockhampton, Australia (23° S. lat.) The plant is readily propagated from root cuttings and is otherwise of easy cultivation. The fruit is of medicinal, particularly antidysenteric, value. The root and the leaves are also used medicinally." (*Extract from Von Mueller's Select Extra-Tropical Plants.*) (For previous introduction see S. P. I. No. 19367.)

22958 to 22960. VIGNA UNGUICULATA (L.) Walp. **Cowpea.**

From Mount Silinda, Malsetter District, Rhodesia, South Africa. Presented by Rev. Columbus C. Fuller. Received June 13, 1908.

The following seeds. Descriptions of varieties by Mr. H. T. Nielsen:

22958. Black with gray specks. The seed has the same general appearance as many of the hybrids between *Black* and *Iron.*

22959. Red. Similar to *Red Ripper*, but seed is larger.

22960. *Clay.*

22961. PHALARIS COERULESCENS Desf.

From Bathurst, New South Wales, Australia. Presented by Mr. R. W. Peacock, manager, Experimental Farm, through Mr. C. V. Piper. Received June 13, 1908.

"This new fodder plant has been tried by Mr. J. Furphy, of Hill End, in the Moe District, West Gippsland, who says it supplies what has long been wanted—a winter feed for stock, as it resists the frosts and keeps growing right through the winter months. Mr. Furphy states that he obtained a few plants and transplanted them at the end of April of last year, putting them out in drills 3 feet apart and 2 feet in the drills. By the end of June they had made a growth of 2 feet, sending out shoots until, by the end of the season, as many as 167 stems had been produced by one plant, the highest averaging 7 feet, while some of the stronger stems obtained a height of 8½ feet, the clumps measuring 2 feet across. Although it was a severe winter, not a yellow leaf could be seen, and the growth was continuous, with nice, succulent blades up to the flowering stems. The roots are fibrous, the foliage very dense, and color a bright green in the middle of winter. It seems to succeed in the colder districts where other plants do not thrive. Autumn planting is recommended, and Mr. Furphy favors giving the plants plenty of room. His plot yielded at the rate of 60 bushels of seed and 8 tons of hay to the acre. He cut the crop at the end of January, this year, and in 45 days it had grown a second crop nearly 3 feet high, the weather meantime being very dry. As to the milk-producing qualities of the grass, judging by its succulent quality and the abundance of the crop, Mr. Furphy is convinced that it will prove a most valuable fodder for the dairy herd." (*Journ. Dept. Agric. Western Australia*, vol. 15, p. 652. 1907.)

22962. MEDICAGO SATIVA L. **Alfalfa.**

From about 50 miles south of Lan Chow, Kansu, China. Presented by Rev. David Ekvall, Tehtao, Kansu, China, through Mrs. Edward Q. Knight, Takoma Park, D. C. Received June 16, 1908.

"The natives say this seed must be sown with something else to grow well." (*Ekvall.*)

22963 to 22968.

From Argentina, South America. Presented by Señor Mario Estrada, Division of Agriculture, Buenos Aires. Received June 10, 1908.

22963 to **22965**. From province of Buenos Aires.

22963. ERAGROSTIS sp.

22964. ERAGROSTIS sp.

22965. RUMEX CRISPUS *L.*

22966. ANDROPOGON SACCHAROIDES Sw.

From province of Santa Fé.

22967. BRIZA sp.

From province of Santa Fé.

22968. PANICUM BERGI Arech.

From province of Buenos Aires.

22969. GLADIOLUS SALMONEUS Baker. **Gladiolus.**

From Merea, Durban, Natal. Presented by Dr. J. Medley Wood, director, Natal Botanic Gardens. Received June 18, 1908.

"Corms of a handsome but not very common species." (*Wood.*)

22970. MANGIFERA INDICA L. **Mango.**

From Bombay Province, India. Procured by Mr. Wm. H. Michael, consul-general, Calcutta, India. Received June 19, 1908.

White Alfonso. "The Advocate of India has this to say of the *White Alfonso* mango: 'We have at this moment on the office table a specimen of mango which has been sent to us, the like of which has never before been grown. It is a *White Alfonso*, perfect in shape, with a beautiful satin skin and a subtle aroma which faithfully indicates the delicate flavor of its golden pulp. It is a triumph in every respect, and with the smallest stone for its size. Yet it is of gigantic weight and proportions. A good specimen of the *Golden Alfonso*, so far our best mango, does not weigh more than about 4 ounces. The *White Alfonso* just fails to tip the beam at the weight of 2¼ pounds. The *White Alfonso*, or *Safeda Afoos*, is grown about 20 miles outside Bombay city, in the direction of Borivill, and although the fruit has reached gigantic size, this is the first occasion on which the trees have borne fruit. There is only a limited supply at present, but the new fruit seems destined to wrest the pride of place from the still glorious specimen, the *Golden Alfonso*. A peculiarity of the pulp is its pale rose colored hue. The few which have been offered to the public have found ready purchasers at 15 rupees, or $5 per dozen.'" (*Michael.*)

22971. CACARA EROSA (L.) Kuntze. **Hicama.**

From Guadalajara, Mexico. Presented by Señor Luis Rosas, through Mr. Frederic Chisolm. Received June 20, 1908.

"The plant, which in both Guam and the Philippines bears its Mexican name, was probably brought (to Guam) from Mexico. It is now common in the woods, climbing among the bushes and trees and twining about everything with which it comes in contact. The young root is much like a turnip in shape and consistency, and is easily peeled like a turnip. It is usually eaten raw, and may be prepared with oil and vinegar in the form of a salad. According to Dr. Edward Palmer it is extensively cultivated in Mexico, where the natives pinch off the blossoms and seed pods, giving as a reason that if the seeds are allowed to mature the roots are not good. In Mexico the roots are much eaten raw, but are also pickled, boiled in soup, and cooked as a vegetable. As they come from the ground they are crisp, sweet, juicy, and of a nutty flavor. They are nourishing and at the same time quench the thirst, so that they are much liked by travelers. One way of preparing the raw roots is to cut them in thin slices and sprinkle sugar over them. They may also be boiled and prepared with batter in the form of fritters, and in Mexico they are often minced or grated, and with the addition of sugar, milk, eggs, and a few fig leaves for flavoring, made into puddings." (*Safford's Useful Plants of Guam.*)

"The Jicama (Hicama) de agua is one of the most widely popular vegetables grown in Mexico, and when in season one rarely meets an Indian who is not munching a large specimen. For the table I have seen them peeled, thinly sliced, and served with sliced oranges, forming the dessert dish called 'picò de gallo'—cock's bill. In the hot season the tubers are delightfully refreshing, whether eaten out of hand or sliced as a made dish. The plant cultivated is usually planted either in hills or on the ridge of ordinary rows, and should be given rather careful cultivation, the tips of the vines and all flower buds being pinched off in order to make the plant develop large tubers." (*Chisolm.*)

22972 and 22973. MEDICAGO SATIVA L. **Alfalfa.**

From Chile. Presented by Mr. Rea Hanna, American consul, Iquique. Received June 19, 1908.

22972.

From Pica, Tarapacá, Chile. "The man from whom I procured it says that the alfalfa from which it was obtained has been planted 12 years and produces from six to eight crops per year." (*Hanna.*)

22973.

From Matilla, Chile. "I do not know that there is any difference between this and the above (S. P. I. No. 22972), except that it comes from another small oasis near Pica. Many of these fields have been planted for nearly 100 years without reseeding and give remarkable crops, and the plants may have acquired some new qualities of virility from the wonderful soil and atmosphere." (*Hanna.*)

22974 to 23038.

From China. Received through Mr. Frank N. Meyer, agricultural explorer, and brought by him to the Plant Introduction Garden, Chico, Cal., June, 1908.

The following plants:

22974. SOPHORA JAPONICA L.

From Fengtai, near Peking, Chihli, China. "(No. 331, Mar. 31, 1908.) The well-known Pagoda tree, of which there are two varieties in China, one with a whitish bark and the other with black. Both varieties are supposed to be among this lot, but it is not until after a few years that one is able to see the difference between the trees; when young they all look alike. Chinese name *Huai shu.*" (*Meyer.*)

22975. ULMUS PUMILA L. **Elm.**

From Fengtai, near Peking, Chihli, China. "(No. 332, Mar. 31, 1908.) The Chinese elm, used all over northern China and Manchuria as an avenue, shade, and timber tree. Resists droughts, extremes of heat and cold, and neglect remarkably well; will be a good shade tree for the semiarid northern regions of the United States. The Chinese carts are mainly constructed from the wood of this tree. Chinese name *Dja yü shu*, meaning family elm tree." (*Meyer.*)

22976. ERIOBOTRYA JAPONICA (Thunb) Lindl. **Loquat.**

From Tangsi, Chehkiang, China. "(No. 333, Mar., 1907, and Apr., 1908.) A loquat said to bear white or at least very pale yellow colored fruits, which have a very fine flavor. A rare variety. Chinese name *Pai bibaw.*" (*Meyer.*)

22977. MYRICA NAGI Thunb.

From Tangsi, Chehkiang, China. "(No. 334, Mar., 1907.) The so-called 'strawberry tree' of central China; produces nice edible fruits which can be preserved or used in pastries, fruit sirups, etc. Chinese name *Yang mae.*" (*Meyer.*)

22978. VIBURNUM MACROCEPHALUM Fortune.

From Soochow, Kiangsu, China. "(No. 335, Apr. 26, 1908.) The giant Chinese snowball. A tall bush bearing enormous umbels of white flowers, sometimes over 1 foot in diameter. The plants are mostly used

22974 to 23038—Continued.

in gardens to cover up a corner or hide a wall, but they are also often grafted upon the wild form which has single flowers, and grown then in a dwarfed state in tubs or pots. Probably not hardy north. Chinese name *Mu bun sen chu*." (*Meyer.*)

22979. ILEX CORNUTA Lindl. & Paxt. (?)

From Soochow, Kiangsu, China. "(No. 336, Apr. 26, 1908.) The Chinese holly. A very ornamental bush or small tree loaded in winter with scarlet berries. A slow grower, and probably not hardy north. Chinese name *Ta hu tse*." (*Meyer.*)

22980. CAESALPINIA sp.

From Soochow, Kiangsu, China. "(No. 337, Apr. 26, 1908.) A very rare shrub, only one specimen in Soochow. Not hardy north. Chinese name *Pai chi mei*." (*Meyer.*)

22981. CARAGANA sp.

From Soochow, Kiangsu, China. "(No. 338, Apr. 26, 1908.) A low-growing Caragana, bearing bronze-yellow flowers; is cultivated in pots as an ornamental plant and is far from being common. Probably not hardy north. Chinese name *Fei chong*." (*Meyer.*)

22982. LOROPETALUM CHINENSE R. Br.

From Soochow, Kiangsu, China. "(No. 339, Apr. 26, 1908.) An ornamental, evergreen shrub, sometimes growing into a small tree, bearing small, elliptical, dark green leaves, while in spring it is covered with masses of white, fringed flowers, which are delightfully fragrant; it is very rarely found cultivated, and wild specimens do not stand transplanting readily. Chinese name *Chuck mei*." (*Meyer.*)

22983. AZALEA sp. **Azalea.**

From Soochow, Kiangsu, China. "(No. 340, Apr. 26, 1908.) A rare variety of Azalea having wine purple colored, semidouble flowers ('hose-in-hose,' this variation is called). Chinese name *Tsze ja tau*." (*Meyer.*)

22984. CYDONIA sp. **Quince.**

From Soochow, Kiangsu, China. "(No. 341, Apr. 26, 1908.) A very small form of a quince. Chinese name *Lo hai tang*." (*Meyer.*)

22985. (Undetermined.)

From Soochow, Kiangsu, China. "(No. 342, Apr. 26, 1908.) *Zelkova* or *Ulmus*. Often dwarfed by the Chinese and grown in all kinds of earthen vessels; also found wild in the mountains. Chinese name *Yu shu*." (*Meyer.*)

22986. ELAEAGNUS PUNGENS Thunb. (?)

From Soochow, Kiangsu, China. "(No. 343, Apr. 26, 1908.) A tall shrub or small tree with silvery leaves, flowering in early spring with masses of tiny, pale yellow colored flowers which emit a delightful perfume and attract many honey-collecting insects. May serve for a hedge tree, as it is somewhat spiny and grows very dense. Probably not hardy north. Chinese name *Tan kwan tou*." (*Meyer.*)

22987. (Undetermined.)

From Soochow, Kiangsu, China. "(No. 344, Apr. 26, 1908.) Small-leaved, evergreen shrub; grown rarely as a dwarfed tree in vessels. Chinese name *Chuck mei tsang*." (*Meyer.*)

22974 to 23038—Continued.

22988. LIGUSTRUM sp.

From Soochow, Kiangsu, China. "(No. 345, Apr. 26, 1908.) A dwarfy privet of spreading habit." (*Meyer.*)

22989. PRUNUS sp. **Plum.**

From Soochow, Kiangsu, China. "(No. 346, Apr. 26, 1908.) A red-flowered plum, much used for house and shop decoration during Chinese New Year; it is generally grafted upon *Amygdalus davidiana* (Carr.) Dipp., the remarkable hardy 'original' peach. These plants are being forced by the thousands and sell for high prices. Chinese name *Hong mei.*" (*Meyer.*)

22990. PRUNUS sp. **Plum.**

From Soochow, Kiangsu, China. "(No. 347, Apr. 26, 1908.) A white-flowered plum; for remarks see the preceding number (S. P. I. No. 22989). Chinese name *Lu mei.*" (*Meyer.*)

22991. PRUNUS JAPONICA Thunb. (?)

From Soochow, Kiangsu, China. "(No. 348, Apr. 26, 1908.) A dwarfy shrub, bearing dense masses of small, double, white flowers on its slender branches. Apparently the white variety of No. 669 (S. P. I. No. 23007); as such see this number for remarks. Chinese name *Sui li.* Can be propagated by slips with a heel left to them." (*Meyer.*)

22992. RIBES sp. **Currant.**

From Soochow, Kiangsu, China. "(No. 349, Apr. 26, 1908.) A currant grown in pots and in tubs; rarely seen. Apparently collected in the mountains. Chinese name *Chi ching.*" (*Meyer.*)

22993. SPIRAEA sp.

From Soochow, Kiangsu, China. "(No. 350, Apr. 26, 1908.) A bushy, white-flowered Spiraea. Fit to be grown as an ornamental garden shrub. Chinese name *Yang teng.*" (*Meyer.*)

22994. DAPHNE sp. (?)

From Soochow, Kiangsu, China. "(No. 351, Apr. 26, 1908.) An ornamental, spring-flowering shrub. Chinese name *Chi hsian.*" (*Meyer.*)

22995. EUONYMUS ALATUS (Thunb.) Rupr.

From Soochow, Kiangsu, China. "(No. 352, Apr. 26, 1908.) A deciduous shrub, having characteristic four-winged, white-colored fruits hanging down in long peduncles, which contrast greatly with the bright scarlet hues of the leaves in autumn. Chinese name *Pau shu.*" (*Meyer.*)

22996. (Undetermined.)

From Soochow, Kiangsu, China. "(No. 353, Apr. 26, 1908.) Ericaceous shrub. A very rare shrub, having glossy, green, laurel-like leaves and bearing red, bent-down flowers. Not very hardy. Chinese name *Yu kwei.*" (*Meyer.*)

22997. LESPEDEZA sp.

From Soochow, Kiangsu, China. "(No. 354, Apr. 26, 1908.) A low, shrubby Lespedeza, with large pinnate leaves and bearing graceful racemes of flowers, either purple or white, as there are two varieties. Can be used to advantage in small gardens and in rockeries; also as pot plants. Probably not quite hardy. Chinese name *Lu chuen yuen.*" (*Meyer.*)

22974 to 23038—Continued.

22998. Carissa bispinosa (L.) Desf.

From Soochow, Kiangsu, China. "(No. 355, Apr. 26, 1908.) A strange, beautiful, little plant; very spiny, with very small, dark green, glossy leaves and bright red berries; very ornamental, and well fit for table decoration during the winter holidays. Wants cool, shady situations and is not hardy in the cold-wintered regions. Chinese name *Shau hu tsi.*" (*Meyer.*)

22999. Hedera sp.

From Soochow, Kiangsu, China. "(No. 356, Apr. 26, 1908.) A rare, variegated form of the Chinese yellow-berried ivy. Probably not hardy north. Chinese name *Yu chuck.*" (*Meyer.*)

23000. (Undetermined.)

From Soochow, Kiangsu, China. "(No. 357, Apr. 26, 1908.) A purple-flowered, terrestrial orchid, said to grow wild near Hangchow. An ornamental plant for gardens in the southeastern United States. Chinese name *Yo lan.*" (*Meyer.*)

23001. (Undetermined.)

From Soochow, Kiangsu, China. "(No. 358, Apr. 28, 1908.) A red-flowering lily. Chinese name *Yang pou an.*" (*Meyer.*)

23002. (Undetermined.)

From Soochow, Kiangsu, China. "(No. 359, Apr. 26, 1908.) A white-flowering lily. Chinese name *Oue su.*" (*Meyer.*)

23003. Acorus sp.

From Soochow, Kiangsu, China. "(No. 360, Apr. 26, 1908.) A pigmy variety of a sweet flag; grown in small pots in saucers of standing water; fit to be grown in aquariums as a small, ornamental plant. Chinese name *Chang pu.*" (*Meyer.*)

23004. (Undetermined.)

From Hangchow, Chehkiang, China. "(No. 361, June 27, 1907.) An epiphytic orchid, obtained from Bishop G. E. Moule, in whose garden it grows on a cryptomeria tree in the shade." (*Meyer.*)

23005. (Undetermined.)

From Ningpo, Chehkiang, China. "(No. 362, July 3, 1907.) An epiphytic orchid, coming from the neighboring mountains and sold on the streets as medicine." (*Meyer.*)

23006. Buddleia asiatica Lour.

From Shanghai, Kiangsu, China. "(No. 363, May 15, 1908.) A very ornamental plant for winter flowering in a moderately warm greenhouse; has beautiful white drooping racemes, and the potted plants can be used very advantageously in decorative work. It needs about the same cultural treatment as the *Euphorbia pulcherrima* Willd.—that is, it needs a rest in spring and to be kept dry; after that the old plants can be cut back or young plants can be made from the young sprouts." (*Meyer.*)

23007. Prunus japonica Thunb. (?)

From Hangchow, Chehkiang, China. "(No. 669, June 28, 1907.) A low shrub with elliptical, lanceolate leaves, covered in spring with masses of small, double, rosy flowers; much used in forcing during the Chinese holi-

22974 to 23038—Continued.

days (January and February); may also be used for planting out in beds or rockeries. Chinese name *Bai loa.*" (*Meyer.*)

23008. VIBURNUM TOMENTOSUM Thunb.

From Hangchow, Chehkiang, China. "(No. 670, June 28, 1907.) A Chinese snowball bearing masses of short, white umbels in early summer; somewhat stiff in appearance, but still very ornamental; often grown in pots when dwarfed, but mostly seen as a garden shrub growing as high as 12 feet. Chinese name *Geh dyo tsu.*" (*Meyer.*)

23009. RUBUS ROSAEFOLIUS Smith.

From Hangchow, Chehkiang, China. "(No. 671, June 28, 1907.) Flowering in early summer with great masses of large, white, double flowers. Often grown in pots or tubs; also seen in gardens, where it has been planted for covering up an old wall or an unsightly place. Spreads rapidly through the ground by means of its suckers. Chinese name *Yang ching yen tcung.*" (*Meyer.*)

23010. LARIX sp.

From Hangchow, Chehkiang, China. "(No. 672, June 28, 1907.) A pretty larch much grown as a pot plant when dwarfed; if planted out, it grows into a medium-sized tree. Seems to be able to grow on sterile mountain sides and may be fit for forestation purposes in the southeastern United States. Chinese name *Ching sung.*" (*Meyer.*)

23011. LYCHNIS FULGENS Fisch. (?)

From Hangchow, Chehkiang, China. "(No. 673, June 28, 1907.) An herbaceous perennial of a dwarfy habit, bearing brilliant scarlet flowers. Grown as an ornamental pot plant by the Chinese. Chinese name *San dia lau yang.*" (*Meyer.*)

23012. BUXUS SEMPERVIRENS L.

From Hangchow, Chehkiang, China. "(No. 674, June 28, 1907.) Var. *lanceolata.* Mostly grown as a dwarf tree in vessels; also seen in gardens as a shrub or small tree, clipped or twisted in many grotesque shapes. Reaches a great age, several centuries. The wood is used in the manufacture of fine combs and knife handles. Chinese name *Kua tse huang yang.*" (*Meyer.*)

23013. (Undetermined.)

From Hangchow, Chehkiang, China. "(No. 675, June 28, 1907.) An evergreen shrub, probably growing into a small tree; bears greenish white, bell-shaped flowers; grown in pots when dwarfed; seen rarely as a garden shrub. Chinese name *Mou li.*" (*Meyer.*)

23014. ASPARAGUS sp.

From Hangchow, Chehkiang, China. "(No. 676, June 28, 1907.) A very small, herbaceous asparagus, attaining a height of only 3 to 5 inches; is used as a lining along paths in small gardens; requires a shady situation." (*Meyer.*)

23015. ASPARAGUS sp.

From Soochow, Kiangsu, China. "(No. 677, Apr. 26, 1908.) A feathery, graceful, herbaceous asparagus; grown as an ornamental pot plant in shady situations. Chinese name *Wen chu.*" (*Meyer.*)

22974 to 23038—Continued.

23016. Asparagus sp.

From Shanghai, Kiangsu, China. "(No. 678, May 12, 1908.) A plumy, herbaceous asparagus, used as an ornamental pot plant and as cut green in bouquets; requires a shady situation." (*Meyer.*)

23017. Pinus bungeana Zucc. **Pine.**

From Taiyuanfu, Shansi, China. "(No. 679, Mar. 13, 1908.) The beautiful and striking white-barked pine tree, growing to be very old, perhaps up to twenty centuries. These trees are said to come from Honan. Chinese name *Pai kua sung shu.*" (*Meyer.*)

23018. Pinus bungeana Zucc. **Pine.**

From Fengtai, near Peking, Chihli, China. "(No. 680, Mar. 31, 1908.) These trees are said to come from central Shansi. For further remarks see preceding number (S. P. I. No. 23017)." (*Meyer.*)

23019. Pinus bungeana Zucc. **Pine.**

From Soochow, Kiangsu, China. "(No. 681, Apr. 26, 1908.) These trees are called here *Pai pu sung.* For further remarks see Nos. 679 and 680 (S. P. I. Nos. 23017 and 23018)." (*Meyer.*)

23020. Abies sp. **Fir.**

From Fengtai, near Peking, Chihli, China. "(No. 682, June 1, 1908.) A rare, bluish fir, valued highly by the Chinese. Probably very hardy in the drier regions of the United States. Chinese name *Lou han sung shu.*" (*Meyer.*)

23021. Abies sp. **Fir.**

From Tientsin, Chihli, China. "(No. 683, Apr. 3, 1908.) The same as the preceding number (S. P. I. No. 23020); as such see remarks applying to it." (*Meyer.*)

23022. Juniperus sp. **Juniper.**

From Fengtai, near Peking, Chihli, China. "(No. 684, Mar. 31, 1908.) A very rare, ornamental variety of juniper of a deep bluish color; not hardy north, and in winter should be stored in a cool greenhouse. These specimens are grafted on to *Thuya orientalis.* Chinese name *Tsui bai.*" (*Meyer.*)

23023. Juniperus sp. **Juniper.**

From Tientsin, Chihli, China. "(No. 685, Apr. 3, 1908.) A specimen of remarkable beauty, also grafted, apparently. Said to come from southwestern Shantung. For further remarks see preceding number (S. P. I. No. 23022)." (*Meyer.*)

23024. Cupressus funebris Endl. (?)

From Fengtai, near Peking, Chihli, China. "(No. 686, Mar. 31, 1908.) A rare, drooping Thuya, grafted upon *Thuya orientalis.* Beloved by the Chinese on account of its queer, characteristic appearance. Not hardy; in winter should be put in a cool greenhouse. Chinese name *Hsien bay.*" (*Meyer.*)

23025. Juniperus chinensis pendula Franchet.

From Fengtai, near Peking, Chihli, China. "(No. 687, Mar. 31, 1908.) A rare and graceful weeping juniper, grafted upon *Thuya orientalis.* Not hardy, in winter should be kept in a cool greenhouse. Chinese name *Ying lou sung.*" (*Meyer.*)

22974 to 23038—Continued.

23026. EPHEDRA sp.

From Taiyuenfu, Shansi, China. "(No. 688, Mar. 13, 1908.) The rare and strange horsetail plant. A hardy, evergreen garden shrub, for arid regions. These plants are said to come from Honan. Chinese name *Ma whou sung.*" (*Meyer.*)

23027. EUONYMUS sp.

From Taiyuenfu, Shansi, China. "(No. 689, Mar. 31, 1908.) A semievergreen Euonymus, loaded in winter with white capsules, out of which peep scarlet berries. Grown drawfed in pots and fit for table decoration during the winter holidays. This plant may not be quite hardy north, as the Chinese keep it in a frostproof cellar in winter. Chinese name *Shi yuen mae.*" (*Meyer.*)

23028. CITRUS LIMONUM Risso (?) **Lemon.**

From Fengtai, near Peking, Chihli, China. "(No. 690, Mar. 31, 1908.) Ornamental lemon. This lemon is grown as a pot plant when dwarfed, and is very much appreciated by the Chinese higher classes as a decorative plant in winter. At that season a small plant often has a dozen large lemons hanging on its branches and sometimes sells for $10. Protect from frost. Can be slipped in sandy soil in flat pots. Chinese name *Hsien yuang.*" (*Meyer.*)

23029. LONICERA sp.

From Tientsin, Chihli, China. "(No. 691, Apr. 3, 1908.) A dwarf honeysuckle grown in pots as an ornamental plant. The flowers are remarkably fragrant in the evening. Seems to be semitender, as the Chinese keep them in pits in winter. Chinese name *Ching yin hua.*" (*Meyer.*)

23030. SYRINGA OBLATA Lindl. (?) **Lilac.**

From Fengtai, near Peking, Chihli, China. "(No. 692, Mar. 31, 1908.) A fragrant, ornamental, large, purple-flowered lilac, growing into a big bush or a small tree; very drought resistant. Chinese name *Tse ting hsien.* This variety and the following one (S. P. I. No. 23031) are often grafted in central China upon high-stemmed *Ligustrum lucidum*, making then a fine effect." (*Meyer.*)

23031. SYRINGA OBLATA Lindl. (?) **Lilac.**

From Fengtai, near Peking, Chihli, China. "(No. 693, Mar. 31, 1908.) A medium-sized, white-flowering lilac. See preceding number (S. P. I. No. 23030) for remarks. Chinese name *Pai ting hsien.*" (*Meyer.*)

23032. SYRINGA sp. **Lilac.**

From Fengtai, near Peking, Chihli, China. "(No. 694, Mar. 31, 1908.) A small-leaved lilac, bearing many panicles of purple flowers, grafted upon a small-leaved privet. Used much in forcing; quite rare and expensive; not hardy. Chinese name *Shau ting hsien.*" (*Meyer.*)

23033. SYRINGA sp. **Lilac.**

From Tientsin, Chihli, China. "(No. 695, Apr. 3, 1908.) A small-leaved lilac, the same species as the preceding number (S. P. I. No. 23032), but apparently of slightly different colors. There are two white-flowering ones among them; otherwise the same remarks apply to it as to No. 694 (S. P. I. No. 23032). Keep them protected from heavy frosts.

22974 to 23038—Continued.

Has a future for the western people as a very graceful, spring-flowering shrub of dwarfy habits." (*Meyer.*)

23034. Rosa xanthina Lindl. **Rose.**

From Fengtai, near Peking, Chihli, China. "(No. 696, Mar. 31, 1908.) A yellow rose, remarkably hardy, resisting drought and extremes of dry heat and dry cold to an unusual degree. For further remarks see Nos. 67, 68, and 254 (S. P. I. Nos. 17469 and 22452)." (*Meyer.*)

23035. Rosa sp. **Rose.**

From Tientsin, Chihli, China. "(No. 697, Apr. 3, 1908.) A red rose said to be very floriferous, but the flowers are small. Hardy in the uncongenial climate of Tientsin, where it passes the winter unprotected in the open. Chinese name *Ten hong shoo mei kwei.*" (*Meyer.*)

23036. Rosa sp. **Rose.**

From Soochow, Kiangsu, China. "(No. 698, Apr. 26, 1908.) Small-leaved red rose; rare. Chinese name *Hong si ya chi.*" (*Meyer.*)

23037. Rosa sp. **Rose.**

From Soochow, Kiangsu, China. "(No. 699, Apr. 26, 1908.) Small-flowered white rose. Apparently a rambler. Chinese name *Pai si ya chi.*" (*Meyer.*)

23038. Rosa sp. **Rose.**

From Soochow, Kiangsu, China. "(No. 700, Apr. 26, 1908.) Small-flowered yellow rose. Apparently a rambler. Chinese name *Hwang si ya chi.*" (*Meyer.*)

23039. Enterolobium cyclocarpum (Jacq.) Griseb.

From Gorgona, Canal Zone, Panama. Presented by Mr. V. Allan Rutherford. Received June 3, 1908.

"This tree grows 40 feet high, covering a radius of 20 to 30 feet, and forms a beautiful shade. It bears a pod about 5 to 6 inches and is good food for cattle. There are other peculiar features of the tree that make it valuable for shade; when 4 or 5 years old it is from 25 to 30 feet high. I think this tree would make a fine shade tree for the South and Southwestern States, where there is so much prairie land." (*Rutherford.*) (See No. 11592 for further description.)

23040. Cacara erosa (L.) Kuntze. **Hicama.**

From San Juan, P. R. Presented by Mr. Wm. Allan, through Mr. C. V. Piper. Received June 23, 1908.

See No. 22971 for description.

23041 to 23199. Solanum tuberosum L. **Potato.**

From Chile, South America. Procured by Mr. José D. Husbands, Limávida via Molina, Chile, at the request of Prof. L. C. Corbett. Received June 24, 1908.

The following tubers, descriptions of varieties by Mr. W. V. Shear:

23041 to 23086.

From the archipelago of Chiloé. "The archipelago of Chiloé is situated in the southern part of Chile and is the indigenous home of potato tubers (*Solanum tuberosum*). It is from here that the Spanish obtained

23041 to 23199—Continued.

23041 to 23086—Continued.

the potatoes which they took to Spain early in the sixteenth century, and thereby gave to the civilized world the 'Irish' potatoes of Chilean nativity. The flavors, size, forms, abundant production, and general excellence of 'Chiloé potatoes' are well known and justly famous; unequaled and unapproached in any part of the world, they stand alone as the highest classed potatoes known. It is surprising that all these beauteous tubers still remain solely in their original birthplace. The Chilenos have been and are still indifferent to the class of potatoes they plant and eat. The remoteness of Chiloé and the want of kindred conditions to produce like results elsewhere may play a part in the fact that Chiloé potatoes are to be found only in Chiloé. Island intercommunication is rare and extremely hazardous. Swift ocean currents run riot among them and there are also unknown rocks, exposing the voyager to perils of no ordinary character. Commerce is infrequent and deficient, as well as extremely limited, except in parts of the island of Chiloé itself. Rare and dangerous navigation is costly. Potatoes are the sole food of the inhabitants. They make bread of pounded raw potatoes mixed with a little grease. There are over 250 known wild varieties, so long cultivated as to have become classes of potatoes in the island of Chiloé alone, without considering the archipelago of Gualtecas and Chonos and the hundreds of islands which form the grand archipelago of Chiloé. The following are different wild varieties of *Solanum tuberosum*, which have become fixed classes by long cultivation." (*Husbands.*)

23041. Small, oblong, violet-colored tubers.

23042. Medium-sized, yellowish, round to oblong, flattened tubers.

23043. Medium-sized, long, cylindrical, white tubers.

23044. Round to oblong violet tubers.

23045. Small, roundish, uneven, deep-eyed, purple tubers.

23046. Small, oblong, uneven, deep-eyed, violet tubers.

23047. Medium-sized, round, deep-eyed, violet tubers.

23048. Medium-sized, oblong, compressed, deep-eyed, mottled violet and cream tubers.

23049. Large, roundish, smooth, white tubers, flattened on one side near stem end.

23050. Medium-sized, oblong, white tubers.

23051. Small, roundish, uneven, mottled violet tubers.

23052. Medium-sized, uneven, compressed, deep-dyed, pinkish mottled, russet tubers.

23053. Medium-sized, oblong, shallow-eyed, pink tubers.

23054. Medium-sized, roundish flattened, pink tubers.

23055. Long, cylindrical, white tubers.

23056. Medium-sized, round to oblong, compressed, violet tubers.

23057. Small to medium-sized, roundish oblong, somewhat flattened, yellow tubers.

23058. Medium-sized, round, flattened, medium deep eyed, mottled purple and yellow tubers.

23059. Medium-sized, round to oblong, uneven, white tubers.

23041 to 23199—Continued.

23041 to 23086—Continued.

23060. Medium-sized, oblong, white tubers.

23061. Medium-sized, round to oblong, light violet mottled tubers.

23062. Round to oblong violet-mottled tubers.

23063. Small, round to oblong, white tubers.

23064. Small, round, deep-eyed, yellow tubers.

23065. Medium-sized, round, yellow tubers.

23066. Medium-sized, cylindrical, pink tubers.

23067. Medium-sized, round, uneven, deep-eyed, yellow tubers.

23068. Medium-sized, roundish flattened, violet tubers.

23069. Large, round, flattened, shallow-eyed, yellow tubers.

23070. Medium-sized, round to oblong, violet-mottled tubers.

23071. Small, oblong, white tubers.

23072. Small, round, white tubers.

23073. Large, oblong, somewhat flattened, yellow tubers.

23074. Medium-sized, oblong, white, violet-tinged tubers.

23075. Small, round, yellow tubers.

23076. Large, oblong, flattened, mottled violet and white, shallow-eyed tubers.

23077. Medium-sized, round, uneven, deep-eyed, mottled violet and yellow tubers.

23078. Medium-sized, round, uneven, deep-eyed, pink tubers

23079. Medium-sized, uneven, white tubers.

23080. Medium-sized, round, deep-eyed, pinkish yellow tubers.

23081. Large, smooth, oblong, somewhat flattened, yellow tubers. Handsome.

23082. Medium-sized, round to oblong, somewhat flattened, yellowish tubers.

23083. Small, round, deep-eyed, yellow tubers.

23084. Small, oblong, somewhat flattened, yellow tubers.

23085. Medium-sized, round to oblong, smooth, yellow tubers.

23086. Round to oblong, deep-eyed, pink tubers.

23087 to 23103.

From archipelago of Chiloé. "Wild sorts annually resow their seeds, producing, by nature's care alone, limitless thousands of undomesticated tubers of every color and form, all of which are delicious eating. Among the islands there are new and distinct strains, whose tubers and plants have no similarity to known varieties. I gathered one. It had a snow-white skin with small, bright crimson eyes which were shaded with dark crimson. The flesh was sweet as sugar. The plant was upright, thick, and waxlike; the leaves were like a three-leafed clover; no one would have taken it for a potato plant. This, as well as many other kinds of wild potatoes, matures in the spring month of October, equivalent to May in the United States. All endure hard frosts, but the ground is never frozen. They remain in the wet about five months during the continuous rains of a Chilean winter, and seem to like it. In this collection there are many potatoes having a like form and appearance; they

23041 to 23199—Continued.

23087 to 23103—Continued.

are not duplicates, but are taken from different islands, or at a great distance upon the mainland, each under separate and different conditions of soil, plant food, moisture, etc. Tubers of medium to small size are included. Wild potatoes are especially fine baked. Seedlings are inclined to dissolve when boiled, more especially the black-skinned kinds, until after they have been cultivated a year or two.

"This collection is totally unknown to any botanist in Chile or to anyone except in parts of the several localities where found. Even these people seemed surprised to learn they had so many kinds of potatoes growing unknown about them. Many thousands have been dug to make up this assortment. All wild seedlings show some difference, but generally not sufficient to be classed as new strains. It would be wise, however, to plant all that grow here but for the expense and difficulties of transportation inland. Travel is confined to horseback. It is laborious and perplexing to properly arrange and transport large quantities of such tubers in a condition fit to send to the United States. They resent the slightest bruise. I do not give the names of potatoes sent, as they have no significance, being local names from the Chilote Indian dialect. In other districts having other tribes the same tubers are called by other names having no general meaning; local appellations are omitted. The potatoes sent are but selections from many kinds in their native, indigenous, uncultivated state." (*Husbands.*)

23087. Small, oblong, yellow, smooth tubers.

23088. Small, oblong, deep-eyed, mottled violet and yellow tubers.

23089. Small, round, violet-colored tubers.

23090. Small, round, violet tubers.

23091. Long, slender, cylindrical, violet tubers.

23092. Small, round, uneven, purple tubers.

23093. Medium-sized, oblong, pink, rather deep eyed tubers. Large enough for food.

23094. Long, curved, cylindrical, numerous and deep eyed, violet and white tubers.

23095. Small, round, yellow tubers.

23096. Small, round, flattened, pink tubers.

23097. Small, oblong-conical, pink tubers.

23098. Small, round to oblong, mottled pink and yellow tubers.

23099. Small, round, pinkish yellow tubers.

23100. Small, roundish flattened, violet tubers.

23101. Small, round, yellow tubers.

23102. Small, oblong, pinkish yellow tubers.

23103. Long, cylindrical, somewhat curved, deep purple tubers.

23104 to 23114.

From the mainland along the coast of the province of Valdivia. "In the mountainous southern province of Valdivia grow potatoes of other sorts, but still of rare excellence as to flavor, form, size, and yield. These are selected as samples representing the many kinds to be had there. Those along the coast are said to be of a richer flavor or sweeter taste

23041 to 23199—Continued.

23104 to 23114—Continued.

than those of the interior. To me, they are not unlike the Chilotes. However, I have tested so many kinds lately that they all taste alike for the moment. Some of these are extra early; none very late. In this province their names are from the Mapocho Indian dialect. The following are wild varieties which have become permanent strains by long cultivation." (*Husbands.*)

23104. Large, round, deep-eyed, yellowish white tubers.

23105. Small, round, somewhat uneven, white tubers.

23106. Medium-sized, round, somewhat uneven, yellow tubers.

23107. Very long, rather uneven, cylindrical, pinkish yellow tubers.

23108. Small, oblong, white tubers.

23109. Medium-sized, dumb-bell shaped, violet-colored tubers.

23110. Medium-sized, round, uneven, yellow tubers.

23111. Medium-sized, round, uneven, white and violet tubers.

23112. Large, oblong, violet-colored tubers.

23113. Medium-sized, oblong, white tubers.

23114. Long, curved, cylindrical, numerous-eyed tubers.

23115 to 23120.

From the interior of the province of Valdivia. "Potatoes grown in the interior of the province of Valdivia have no especial peculiarities to describe except that they are of extra good form and very productive. While said to be of less flavor and merit than those of the coast, I believe that they are equal in quality, but have different flavors. In the entire south of Chile, including Chiloé, potatoes having red, yellow, or white skins with yellow flesh are the sweetest; boiled, baked, or fried, they are delicious. The names are Mapocho. The following are wild varieties which have become established classes by long cultivation." (*Husbands.*)

23115. Large, smooth, oblong, white tubers.

23116. Medium-sized, oblong, white tubers.

23117. Medium-sized, pink-colored tubers.

23118. Compound, medium-sized, light violet colored tubers.

23119. Large and small, oblong, flattened, smooth, white tubers.

23120. Medium-sized, round, somewhat flattened, smooth, yellow tubers.

23121 to 23134.

From the province of Valdivia, both coastwise and from the interior. "In wild varieties of potatoes the black predominate, nearly all of which mature in the springtime. There are many kinds formed and new ones constantly being created by self-sown seeds. Like all wild Chile potatoes they are extra-fine eating. If planted they increase in size for 4 or 5 consecutive years, at which time they reach perfection of size and fixed flavors, and may be considered as standard classes of potatoes. The following are still different wild, uncultivated varieties." (*Husbands.*)

23121. Very small, round, purple tubers.

23122. Small, round, white tubers.

23041 to 23199—Continued.

23121 to 23134—Continued.

23123. Small, uneven, violet-colored tubers.

23124. Very small, round, pinkish yellow tubers.

23125. Very small, round, violet-colored tubers.

23126. Small, round, uneven, pink tubers.

23127. Small, round, yellow tubers.

23128. Small, round, uneven, mottled violet and yellow tubers.

23129. Very small, round tubers; some white, some violet, and some purple with yellow eyes.

23130. Small, round, mottled purple and yellow tubers.

23131. Small, round, purple tubers.

23132. Small, long, cylindrical, purple tubers.

23133. Small, round, pinkish yellow tubers.

23134. Small, compound, yellow tubers.

23135 to 23160.

From the far interior in the vicinity of the volcano Llima. "The following are two-year-old seedlings; are a rare lot and all of superb quality. Some are extra-long keepers and do not sprout until planting time, when they are still hard and sound as when harvested.

"These are all distinct varieties. Some have very little plant growth and are great yielders. They will continue to improve by planting. Many are regular in size. In this province potatoes bear names from the Pehuencha Indian dialect." (*Husbands.*)

23135. Medium-sized, compound, violet-yellow tubers.

23136. Small, round, violet tubers.

23137. Small, round, white tubers.

23138. Medium-sized, round to oblong, yellow, deep-eyed tubers.

23139. Small, oblong, violet tubers.

23140. Medium-sized, pinkish yellow, deep-eyed tubers.

23141. Medium-sized, oblong, smooth, violet-colored tubers.

23142. Small, round to oblong, smooth, yellow tubers.

23143. Very small, round, violet-colored tubers.

23144. Very small, round, smooth, violet-colored tubers.

23145. Medium-sized, uneven, deep-eyed, yellow tubers.

23146. Medium-sized, uneven, yellowish tubers.

23147. Small, round, smooth, yellowish tubers.

23148. Small, round, smooth, some yellowish and some violet-colored tubers.

23149. Medium-sized, oblong, yellowish tubers.

23150. Medium-sized, smooth, round, violet-colored tubers.

23151. Medium-sized, round, smooth, medium deep eyed, violet-yellow tubers.

23152. Medium-sized, oblong, smooth, many medium deep eyed, yellowish tubers. "A long keeper."

23153. Small, round, mottled violet and yellow tubers.

23041 to 23199—Continued.

23135 to 23160—Continued.

23154. Medium-sized, oblong, flattened, violet tubers.

23155. Medium-sized, small, oblong, smooth, shallow-eyed, netted-skinned, violet-tinged tubers.

23156. Small, round, violet-tinged tubers.

23157. Small, oblong, yellowish tubers.

23158. Medium-sized, oblong, flattened, smooth, violet-colored tubers.

23159. Medium-sized, round, somewhat uneven, yellowish tubers.

23160. Medium-sized, oblong, numerous and deep-eyed, yellowish tubers.

23161.

From the far interior in the vicinity of the volcano Llima. "A potato from the United States which by being cultivated in Chile has completely changed its shape and flavor. These are sent as samples of what changes may be made by transplanting from a distant part to another having distinct and different conditions in climate, seasons, soil foods, etc. For example, from seaward to remote inland; plain to mountain; and vice versa." (*Husbands.*)

Large, smooth, oblong, flattened, white tubers.

23162.

"A potato from Germany. Originally a round, black-skinned variety. Grown but one year in Chile; still, changes have already commenced." (*Husbands.*)

Medium-sized, oblong, pale violet colored, smooth tubers.

23163.

"A potato from England, *Nignum bonum.* Long cultivated in Chile, it has completely changed by deterioration instead of the usual improvement. From among those taken from the hills, as planted and grown, are found ill-shaped, worthless sorts, suggesting that it has grown back to the worst wild varieties." (*Husbands.*)

Small, white, round to oblong tubers.

23164.

"A southern Chilean potato of a very fine kind, but its irregular shape made it almost useless. Being from the mountainous interior, I removed it to a point far distant upon the seacoast and am making a good-shaped tuber of it." (*Husbands.*)

Medium-sized, oblong, pointed, smooth, shallow-eyed, violet-pink tuber.

23165.

"A Chilean potato of unknown origin." (*Husbands.*)

Very large, oblong, violet-colored tubers.

23166.

"*Papas Blancos*, white potato. The class most generally cultivated in central Chile." (*Husbands.*)

Medium-sized, oblong, white, numerous, and rather deep-eyed tubers.

23167 to 23199.

"Seeds are very scarce at the time potatoes should be gathered. All the following are worth sowing and the seedlings planted and replanted

23041 to 23199—Continued.

23167 to 23199—Continued.

again before throwing them aside. Many a great man was once a worthless baby." (*Husbands.*)

23167 to 23169.

Seed of cultivated kinds.

23170 and 23171.

Seed from cultivated seedlings.

23172 to 23194.

Seed from wild varieties.

23195 to 23198.

Seed from Chiloé, wild varieties.

23199.

Seed of a wild variety.

23201. MELINIS MINUTIFLORA Beauv.

From São Paulo, Brazil. Presented by Dr. H. M. Lane, president, Mackenzie College, through Mr. C. V. Piper. Received June 22, 1908.

"This is known as *Capim catingueiro*, or *melado*, or *gordura*, one of the best forage grasses of this section. It grows well on poor ground and will stand long absence of rain. It also makes good hay." (*Lane.*)

23202. LITCHI CHINENSIS Sonner. **Leitchee.**

From Honolulu, Hawaii. Procured by Mr. J. E. Higgins, horticulturist, Hawaii Experiment Station. Received June 25, 1908.

"Seeds of the large-seeded variety." (*Higgins.*) (For description see Nos. 10670 to 10673, 14888, and 16237 to 16243.)

23203. MEDICAGO SATIVA L. **Alfalfa.**

From Turkestan. Purchased from Mr. H. W. Duerrschmidt, Tashkend, Turkestan. Received June 24, 1908.

Turkestan. "Werny or Tschilik alfalfa, from the most northern alfalfa-producing part of Turkestan." (*Duerrschmidt.*)

23204. TRIGONELLA FOENUM-GRAECUM L. **Fenugreek.**

From Tunis, Tunis. Presented by Mr. F. Foëx, National School of Agriculture, Mexico City, Mexico. Received June 15, 1908.

See No. 7029 for description.

23205. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Shanghai, Kiangsu, China. Presented by Dr. S. P. Barchet, interpreter, American consulate. Received June 30, 1908.

"Similar in appearance to *Ebony*, No. 17254." (*Nielsen.*)

"An important bean for dry rice land. Chinese name *Pu chi.*" (*Barchet.*)

23206. CUCUMIS MELO L.

From Afghanistan. Presented by Mr. L. A. Ault, president, The Ault & Wiborg Company, Cincinnati, Ohio. Received June 29, 1908.

"I ran across this melon in Peshawar, and taken altogether it is the most delicious fruit in the way of a melon that I have ever tasted." (*Ault.*)

23207 to 23232.

From China. Received through Mr. Frank N. Meyer, agricultural explorer, and brought by him to the Plant Introduction Garden, Chico, Cal., June, 1908. Forwarded to Washington, D. C., and received July 6, 1908.

The following seeds:

23207. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Soochow, Kiangsu, China. "(No. 960a, Apr. 27, 1907.) A large, greenish soy bean, grown around Soochow on the rather low-lying lands. Used when slightly sprouted as a vegetable. Chinese name *Tsin tou.*" (*Meyer.*)

23208. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Tangsi, Chehkiang, China. "(No. 961a, Apr. 20, 1908.) A large, yellow soy bean, often purplish colored on one side. Considered locally a very good variety. Chinese name *Sian chu tou.* Grows on the ridges around inundated rice fields." (*Meyer.*)

23209. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Tangsi, Chehkiang, China. "(No. 962a, Apr. 20, 1908.) The ordinary variety of yellow soy bean as grown around Tangsi on the ridges and strips of land around and between inundated rice fields. Chinese name *Huang tou.*" (*Meyer.*)

23210. PHASEOLUS ANGULARIS (Willd.) W. F. Wight. (DOLICHOS ANGULARIS Willd.)

From Tangsi, Chehkiang, China. "(No. 963a, Apr. 20, 1908.) Different varieties of small beans, grown by the Chinese on the higher lands in the neighborhood of Tangsi. Used as a vegetable when sprouted; also boiled in soups, and when pounded up with sugar it is used as a sweetmeat in cakes and pastry. Chinese name *Chi tou.*" (*Meyer.*)

23211. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Tangsi, Chehkiang, China. "(No. 964a, Apr. 20, 1908.) A very dark brown colored soy bean, grown near Tangsi; said to be very productive. Chinese name *Tszc pi tou.*" (*Meyer.*)

23212. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Hangchow, Chehkiang, China. "(No. 965a, Apr. 24, 1908.) An early-ripening, yellow soy bean, called the sixth month's bean, meaning ripening in the Chinese sixth month (our July). Chinese name *Lu ya pai mou tou.*" (*Meyer.*)

23213. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Hangchow, Chehkiang, China. "(No. 966a, Apr. 24, 1908.) A yellow soy bean called the seventh month's bean, meaning ripening in the Chinese seventh month (our August). Called in Chinese *Chi ya pai mou tou.*" (*Meyer.*)

23214. VIGNA SESQUIPEDALIS (L.) W. F. Wight.

From Tangsi, Chehkiang, China. "(No. 967a, Apr. 20, 1908.) Chinese string beans, used as a green vegetable like the western kinds. Chinese name *Chang kiang tou.*" (*Meyer.*)

23215. DOLICHOS LABLAB L.

From Tangsi, Chehkiang, China. "(No. 968a, Apr. 20, 1908.) A white bean which is mostly grown for its green pods, which are sliced or broken and when boiled furnish an agreeable vegetable. The dried beans are

23207 to 23232—Continued.

also sparingly used in soups, but only by the better classes, as they are rather expensive. Chinese name *Pai pien tou.*" (*Meyer.*)

23216. CANAVALI ENSIFORME (L.) DC.

From Tangsi, Chehkiang, China. "(No. 969a, Apr. 20, 1908.) A very rare edible bean, used mainly as a stomach-strengthening food, and for this reason only to be had in medicine shops. Said to be an erect grower (?). Chinese name *Tau tou.*" (*Meyer.*)

23217. STIZOLOBIUM sp. (?)

From Mokanshan, Chehkiang, China. "(No. 970a, Apr. 22, 1908.) A wild climbing bean found in a thicket. The pods are covered with bristling hairs, which break off easily in one's skin, but do not cause any harm." (*Meyer.*)

23218. SAPIUM SEBIFERUM (L.) Roxb. **Tallow tree.**

From Tangsi, Chehkiang, China. "(No. 971a, Apr. 23, 1908.) The tallow tree, the seeds of which yield a valuable fatty substance. Grown extensively along the canals in the Chehkiang Province. The best varieties are top-grafted upon seedling stock." (*Meyer.*)

23219. FIRMIANA SIMPLEX (L.) W. F. Wight. (HIBISCUS SIMPLEX L.) (STERCULIA PLATANIFOLIA L. f.)

From Soochow, Kiangsu, China. "(No. 972a, Apr. 27, 1908.) Seeds of a tree called in Chinese *Wu tung tsze;* they are sold in one or two shops as a delicatesse, but are not very tasty. They may turn out to be the ordinary *Firmiana simplex* (L.) (*Hibiscus simplex* L.), which is a great favorite with the Chinese as a shade tree in temple gardens and in courtyards." (*Meyer.*)

23220. PINUS KORAIENSIS S. & Z.

From Soochow, Kiangsu, China. "(No. 973a, Apr. 27, 1908.) Sold as a delicatesse by a few shops, and as such they are not bad. Said to come from Shantung, but I suspect them to have been collected in eastern Siberia from *Pinus mandshurica* or an allied form. Chinese name *Sung tsze.*" (*Meyer.*)

23221. CITRULLUS VULGARIS Schrad. **Watermelon.**

From Hangchow, Chehkiang, China. "(No. 974a, Apr. 24, 1908.) Said to be a very fine variety of yellow-fleshed watermelon. Grown around Hangchow on rather low lands. Chinese name *Huang si kua.*" (*Meyer.*)

23222. CITRULLUS VULGARIS Schrad. **Watermelon.**

From Tangsi, Chehkiang, China. "(No. 975a, Apr. 20, 1908.) A watermelon with yellow flesh, said to be good; growing on low fields around Tangsi. Chinese name *Huang lien kua.*" (*Meyer.*)

23223. CITRULLUS VULGARIS Schrad. **Watermelon.**

From Hangchow, Chehkiang, China. "(No. 976a, Apr. 24, 1908.) Said to be a very fine white-fleshed watermelon. Grown around Hangchow on rather low lands. Chinese name *Pai si kua.*" (*Meyer.*)

23224. CITRULLUS VULGARIS Schrad. **Watermelon.**

From Tangsi, Chehkiang, China. "(No. 977a, Apr. 20, 1908.) A white-fleshed watermelon, grown on low fields around Tangsi. Chinese name *San pai tsa kua.*" (*Meyer.*)

23207 to 23232—Continued.

23225. CITRULLUS VULGARIS Schrad. **Watermelon.**

From Tangsi, Chehkiang, China. "(No. 978a, Apr. 20, 1908.) A red-meated watermelon, grown on lowlands around Tangsi. Chinese name *Wu pi hong lien kua.*

"The region around Tangsi is famous for its good watermelons. Test Nos. 975a, 977a, and 978a (S. P. I. Nos. 23222, 23224, and 23225) on lowlands in the South." (*Meyer.*)

23226. ASTRAGALUS SINICUS L.

From Hangchow, Chehkiang, China. "(No. 979a, Apr. 24, 1908.) A red-flowered leguminous plant; grows wild on lowlands; is also used as a fertilization crop on low-lying fields, being plowed under as a fertilizer for rice. The young leaves are much eaten as a vegetable. Chinese name *Huang tsai.*" (*Meyer.*)

23227. ASTRAGALUS SINICUS L.

From Hangchow, Chehkiang, China. "(No. 980a, Apr. 24, 1908.) A leguminous plant, said to bear red flowers, probably a form of No. 979a (S. P. I. No. 23226); as such give it the same treatment. Chinese name *Hong tsai,* which is probably fictitious." (*Meyer.*)

23228. SESAMUM ORIENTALE L. **Sesame.**

From Tientsin, Chihli, China. "(No. 981a, Apr. 4, 1908.) White sesame seed for a trial in the semiarid Southwestern States. These seeds contain a fine, sweet oil, excellent for culinary purposes. The seeds themselves can be used in the making of candies, taffies, and as a sprinkling on cakes. Chinese name *Pai tse ma.*" (*Meyer.*)

23229. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Tientsin, Chihli, China. "(No. 982a, Apr. 4, 1908.) A dark brown colored soy bean; rare. Said to grow near Tientsin. Used for human food; boiled in soups or as a vegetable when slightly sprouted. Chinese name *Tse doh.*" (*Meyer.*)

23230. ANDROPOGON SORGHUM (L.) Brot. **Kowliang.**

Brown.

From Chusan Islands, China. "(No. 983a, April, 1908.) A tall-growing variety of sorghum, coming from the Chusan Islands, called *Chang tsun.* Obtained from Dr. S. P. Barchet at Shanghai, China." (*Meyer.*)

23231. ANDROPOGON SORGHUM (L.) Brot. **Kowliang.**

Brown.

From Chusan Islands, China. "(No. 984a, April, 1908.) A dwarfy form of a sorghum, coming from the Chusan Islands, called *Tuan tsun.* Obtained from Dr. S. P. Barchet at Shanghai, China." (*Meyer.*)

23232. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Shanghai, Kiangsu, China. "(No. 985a, May 11, 1908.) The *Barchet* soy bean, growing on wet rice lands. Chinese name *Ma liao tou.* Obtained through Dr. S. P. Barchet, of Shanghai, who procured these soy beans from Chinhuafu, in the Chehkiang Province, central China." (*Meyer.*)

23233 to 23262. **Bamboo.**

From China. Received through Mr. Frank N. Meyer, agricultural explorer, June, 1908, and brought by him from China to the Plant Introduction Garden, Chico, Cal.

The following plants:

23233.

From vicinity of Tangsi, Chehkiang, China. "(No. 301, autumn, 1907.) Timber bamboo. Chinese name *Mao tsoh.* The largest and most common kind; attains a height of 100 feet and a diameter at its base of 6 to 8 inches; grows only on mountain slopes, preferably in a rich red loam. Used in many, many ways; for instance, in the manufacture of big ladders, water pipes, gutters, tiles on roofs, construction material for large sheds, etc." (*Meyer.*)

23234.

From vicinity of Tangsi, Chehkiang, China. "(No. 302, autumn, 1907.) Timber bamboo. Second in size of the timber bamboos; grows in valleys and at the foot of mountains. Chinese name *Tae tsoh.* This is utilized in furniture manufacture and for poles and boat-hook handles." (*Meyer.*)

23235.

From vicinity of Tangsi, Chehkiang, China. "(No. 303, autumn, 1907.) A timber bamboo, resembling very much the preceding one (S. P. I. No. 23234). Grows on flat, level land and has a very open stand. Is used for tool handles, small light ladders, etc. Chinese name *Tae tsoh* and also *Kang tsoh.*" (*Meyer.*)

23236.

From vicinity of Tangsi, Chehkiang, China. "(No. 304, autumn, 1907.) Timber bamboo, having long joints, but not a large-growing kind. Much used for basket manufacture when the stems have been split up in long, narrow, flexible strips. Chinese name *Wang kon tsoh.*" (*Meyer.*)

23237.

From vicinity of Tangsi, Chehkiang, China. "(No. 305, autumn, 1907.) Timber bamboo, called the *Stone* bamboo, on account of the stems being very hard. Mostly used in the manufacture of fine bamboo furniture, it being a very strong kind. Chinese name *Sah tsoh.*" (*Meyer.*)

23238.

From vicinity of Tangsi, Chehkiang, China. "(No. 306, autumn, 1907.) Timber bamboo. A variety called the *Wooden* bamboo, having solid stems. It is rather small but strong. Chinese name *Moh tsoh.*" (*Meyer.*)

23239.

From vicinity of Tangsi, Chehkiang, China. "(No. 307, autumn, 1907.) A small but strong variety, called the *Bitter* bamboo. Chinese name *Kow tsoh.*" (*Meyer.*)

23240. PHYLLOSTACHYS NIGRA (Lodd.) Munro.

From vicinity of Tangsi, Chehkiang, China. "(No. 308, autumn, 1907.) Timber bamboo. A small but strong variety, growing on mountain slopes. Used for making walking canes, pipestems, and fancy articles. Chinese name *Yu tsoh,* meaning oil bamboo, on account of its shining stems." (*Meyer.*)

23233 to 23262—Continued.

23241.

From vicinity of Tangsi, Chehkiang, China. "(No. 309, autumn, 1907.) A bamboo growing on rich plains and producing edible shoots. Chinese name *Mao tchin tsoh.*" (*Meyer.*)

23242.

From vicinity of Tangsi, Chehkiang, China. "(No. 310, autumn, 1907.) Vegetable bamboo. An edible bamboo growing on the plains. Chinese name *Oo chin tsoh.*" (*Meyer.*)

23243.

From Tangsi, Chehkiang, China. "(No. 311, autumn, 1907.) Vegetable bamboo. The ordinary edible bamboo grown in nearly every back yard in central China. Chinese name *Pah koh poo chi.*" (*Meyer.*)

23244.

From Tangsi, Chehkiang, China. "(No. 312, autumn, 1907.) Vegetable bamboo. Another common, edible bamboo, abounding on the plains. Chinese name *Hua koh poo chi.*" (*Meyer.*)

23245.

From vicinity of Tangsi, Chehkiang, China. "(No. 313, autumn, 1907.) Vegetable bamboo. A very early variety, producing edible sprouts. Chinese name *Tsao ri tsoh.*" (*Meyer.*)

23246.

From vicinity of Tangsi, Chehkiang, China. "(No. 314, autumn, 1907.) Ornamental bamboo, called the *Purple* bamboo, on account of having bronze reddish colored stems. Nice when in a clump. Chinese name *Tsi tsoh.*" (*Meyer.*)

23247.

From vicinity of Tangsi, Chehkiang, China. "(No. 315, autumn, 1907.) Ornamental bamboo. The stems of this small, ornamental bamboo are used for pipestems and canes. Chinese name *Mae loh tsoh.*" (*Meyer.*)

23248.

From vicinity of Tangsi, Chehkiang, China. "(No. 316, autumn, 1907.) Ornamental bamboo. The noted square bamboo, which is difficult to grow; requires partial shade. The stems are used for canes and pipestems. Chinese name *Fang tsoh.*" (*Meyer.*)

23249.

From vicinity of Tangsi, Chehkiang, China. "(No. 317, autumn, 1907.) Ornamental bamboo. A variety called the *Honey* bamboo. Chinese name *Mih tsoh.*" (*Meyer.*)

23250.

From Tangsi, Chehkiang, China. "(No. 318, autumn, 1907.) A low-growing bamboo, the leaves of which are used for wrapping rice, flour, or millet dumplings, the same as the Mexicans use the hull leaves of the corncobs to boil their tamales in. Chinese name *Tsong mah tsoh.*" (*Meyer.*)

23251.

From Ningpo, Chehkiang, China. "(No. 319, autumn, 1907.) A bamboo from Ningpo, called *Wu tsoh.*" (*Meyer.*)

23233 to 23262—Continued.

23252.

From Ningpo, Chehkiang, China. "(No. 320, autumn, 1907.) A bamboo from Ningpo, called *Loong su tsoh.* A tall, yellow-stemmed variety." (*Meyer.*)

23253.

From Ningpo, Chehkiang, China. "(No. 321, autumn, 1907.) A bamboo from Ningpo, called *Tsin tsoh.*" (*Meyer.*)

23254.

From Ningpo, Chehkiang, China. "(No. 322, autumn, 1907.) A bamboo from Ningpo, called *Huang ko tsoh.*" (*Meyer.*)

23255.

From Ningpo, Chehkiang, China. "(No. 323, autumn, 1907.) A bamboo from Ningpo, called *Man tsoh.*" (*Meyer.*)

23256.

From Ningpo, Chehkiang, China. "(No. 324, autumn, 1907.) A bamboo from Ningpo, called *Tan tsoh.* A tall-growing, green-stemmed variety." (*Meyer.*)

23257.

From Ningpo, Chehkiang, China. "(No. 325, autumn, 1907.) A bamboo from Ningpo, called *Tsze tsoh.* A tall, purple-stemmed variety." (*Meyer.*)

23258.

From Ningpo, Chehkiang, China. "(No. 326, autumn, 1907.) A bamboo from Ningpo, called *Mei lu tsoh.* A variety having spotted stems." (*Meyer.*)

23259.

From Ningpo, Chehkiang, China. "(No. 327, autumn, 1907.) A bamboo from Ningpo, without name." (*Meyer.*)

23260.

From Hangchow, Chehkiang, China. "(No. 328, June 28, 1907.) Square bamboo. Obtained from Dr. Duncan Main at Hangchow. For further remarks see No. 316 (S. P. I. No. 23248)." (*Meyer.*)

23261.

From Fengtai, near Peking, Chihli, China. "(No. 329, June 1, 1907, and Mar. 31, 1908.) The so-called *Hardy* bamboo, growing in gardens in and around Peking and Tientsin, where the climatic conditions are not what might be called favorable for the growth of bamboos. These plants may be trusted to be hardy as far north as Philadelphia, and can be grown commercially farther south, perhaps, to supply flower stakes. Chinese name *Chu tse.*" (*Meyer.*)

23262.

From Soochow, Kiangsu, China. "(No. 330, Apr. 26, 1908.) A very dwarfy bamboo, grown in pots and other vessels as an ornamental plant where it rarely reaches over 1 foot in height; when planted out it seems to grow higher. Chinese name *Feng pi chu.*" (*Meyer.*)

23263. NOTHOFAGUS OBLIQUA (Mirb.) Bl.

From Santa Ines, Chile. Presented by Señor Salvador Izquierdo. Received June 29, 1908.

"The *Roble* of Chile, called *Coyam* by the original inhabitants. It is a tall tree with a straight stem, attaining 3 to 4 feet diameter. The wood is heavy and durable, well adapted for posts, beams, girders, rafters, and joists, but not for flooring. One of the few Chilean trees with deciduous foliage." (*Doctor Philippi.*)

23267 to 23289.

From Chile, South America. Presented by Mr. José D. Husbands, Limávida via Molina, through Mr. C. V. Piper. Received June 24, 1908.

The following seeds:

23267. ZEA MAYS L. **Indian corn.**

23268. NOTHOFAGUS OBLIQUA (Mirb.) Bl. **"Chilean red oak."**

See No. 23263 for description.

23269. QUILLAJA SAPONARIA Mol. **Quillai.**

"A colossal tree, fit not only for loamy but also sandy and peaty soil. The bark is rich in saponin, and therefore valuable for dressing wool and silk; also for various cleansing processes." (*Von Mueller.*)

23270. KAGENECKIA OBLONGA Ruiz & Pav. **Bollen.**

"This is allied to *Quillaja saponaria*, and provides tan bark locally." (*Dr. J. A. de los Rios.*)

23271. DRIMYS CHILENSIS DC. **Canelo.**

"This tree attains in river valleys a height of 60 feet. The wood is never attacked by insects. Bark used for medicinal purposes." (*Extract from Von Mueller.*)

23272. MAYTENUS BOARIA Mol. **Maiten.**

See No. 3394 for description.

23273. CRINODENDRON PATAGUA Mol. **Patagua.**

See No. 3354 for description.

23274. RHEUM sp. (?)

23275. TRITICUM POLONICUM L. (?) **Wheat.**

23276. TRITICUM POLONICUM L. (?) **Wheat.**

23277. ERODIUM MOSCHATUM (L.) L'Herit. **Alfilerilla.**

23278. MELILOTUS INDICA (L.) All.

23279. MELILOTUS INDICA (L.) All.

23280 to 23284. MEDICAGO ARABICA (L.) All.

23285. (Undetermined.)

Grass.

23286. (Undetermined.)

Grass.

23287. TRIFOLIUM PRATENSE L. **Red clover.**

23288. TRIFOLIUM sp. (?)

23289. TRIFOLIUM PRATENSE L. (?)

"Wild pink clover."

23290 to 23312.

From China. Received through Mr. Frank N. Meyer, agricultural explorer, and brought by him to the Plant Introduction Garden, Chico, Cal., June, 1908; forwarded to Washington, D. C., and received July 6, 1908.

The following seeds:

23290. PISUM ARVENSE L. **Field pea.**

From Wutaishan, Shansi, China. "(No. 921a, Feb. 26, 1908.) Peas used as a food, either sprouted or boiled as they are. Grow at 5,000 to 6,000 feet elevation. Chinese name *Wau doh.*" (*Meyer.*)

23291. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Wutaishan, Shansi, China. "(No. 922a, Feb. 26, 1908.) Black soy bean, growing at 5,000 to 6,000 feet elevation. Are considered by the Chinese the best food for their hard-working mules and horses; they must always be boiled before being fed to the animals; otherwise they may cause colic; the Chinese also mix a liberal quantity of sorghum seed and chopped straw with these beans. Chinese name *Ghae doh.*" (*Meyer.*)

23292. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Wutaishan, Shansi, China. "(No. 923a, Feb. 26, 1908.) Yellow soy bean. Growing at 5,000 to 6,000 feet elevation. They are used all through northern China for making bean curd and bean vermicelli. Chinese name *Huang doh.*" (*Meyer.*)

23293. PHASEOLUS VULGARIS L. **Bean.**

From Wutaishan, Shansi, China. "(No. 924a, Feb. 26, 1908.) Red beans, growing at 5,000 to 6,000 feet elevation; they like a black, rich soil. Used as a vegetable when boiled. Chinese name *Lien doh.*" (*Meyer.*)

23294. VICIA FABA L. **Horse bean.**

From Wutaishan, Shansi, China. "(No. 925a, Feb. 26, 1908.) A small horse bean, growing at 5,000 to 6,000 feet elevation. Mostly used as a delicatesse after having been roasted with oil and salt; also eaten as a vegetable when slightly sprouted." (*Meyer.*)

23295. AVENA NUDA INERMIS (Koern.) Asch. & Graeb. **Naked oat.**

From Wutaishan, Shansi, China. "(No. 926a, Feb. 26, 1908.) These oats grow all through the higher mountain districts and form the staple food of the natives; they require apparently a short season for maturing and seem to thrive in quite sterile locations. Chinese name *Yoh ma.*" (*Meyer.*)

23296. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Taichou, Shansi, China. "(No. 929a, Mar. 2, 1908.) Yellow soy beans, found growing on strongly alkaline lands. Chinese name *Huang doh.* For further remarks see No. 923a (S. P. I. No. 23292)." (*Meyer.*)

23297. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Taichou, Shansi, China. "(No. 930a, Mar. 2, 1908.) Black soy bean. Grows on strongly alkaline lands. Chinese name *Ghae doh.* For further remarks concerning their uses see No. 922a (S. P. I. No. 23291)." (*Meyer.*)

23298. CANNABIS SATIVA L. **Hemp.**

From Soolungko, Shansi, Kwohsien District, China. "(No. 931a, Mar. 3, 1908.) Found growing in mountain valleys and considered a good hemp. Chinese name *Shan ma tse.*" (*Meyer.*)

23290 to 23312—Continued.

23299. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Tsintse, Shansi, south of Taiyuanfu, China. "(No. 933a, Mar. 12, 1908.) Black and yellow. A rare local variety of a strange soy bean used as a vegetable when slightly sprouted, and after having been scalded for a few minutes in boiling water is eaten with a salt sauce; the skin must be removed before scalding. Chinese name *Yang yen doh*, meaning sheep's eye bean." (*Meyer.*)

23300. PANICUM MILIACEUM L.

From the plains of northern China. "(No. 943a, autumn, 1907.) Hulled drooping millet. Is eaten all over northern China as a high-class food. Boiled very often with Chinese dates; small, sticky, sweet cakes and simple wholesome candies are also prepared from this grain; tastes very good with milk and sugar as a breakfast or light evening food and may also serve as an infant's food. Chinese name *Huang mi.*" (*Meyer.*)

23301. PHASEOLUS ANGULARIS (Willd.) W. F. Wight.

From Hupehko, Chihli, China. "(No. 947a, Dec. 13, 1907.) A large variety of a gray-blackish bean, which is able to grow on rather sandy and on alkaline lands. Is used as a vegetable when sprouted; also pounded up with sugar and used in small cakes as a stuffing. Chinese name *Ghae shau doh.*" (*Meyer.*)

23302. PHASEOLUS VULGARIS L.

From Hupehko, Chihli, China. "(No. 948a, Dec. 13, 1907.) A large, white bean, used as a vegetable boiled in soups. Growing on sandy and on alkaline lands. Chinese name *Ta pai doh.*" (*Meyer.*)

23303. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Shiling, Chihli, China. "(No. 949a, Jan. 25, 1908.) Yellow soy bean. Chinese name *Ta huang doh.* For further remarks see No. 923a (S. P. I. No. 23292)." (*Meyer.*)

23304. PHASEOLUS ANGULARIS (Willd.) W. F. Wight.

From Peking, Chihli, China. "(No. 950a, Feb. 8, 1908.) A small, red bean, which is used as a sweetmeat and as a stuffing in cakes. Chinese name *Hong shau doh.*" (*Meyer.*)

23305. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Peking, Chihli, China. "(No. 951a, Feb. 8. 1908.) Large, light yellow soy bean. Used mostly as a vegetable when slightly germinated, and eaten with a salt sauce. Chinese name *Ta huang doh.*" (*Meyer.*)

23306. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Peking, Chihli, China. "(No. 952a, Feb. 8, 1908.) Large, black soy bean, green inside. Comes from Manchuria and is used mostly like the preceding number (S. P. I. No. 23305.) Chinese name *Ta ghae doh.*" (*Meyer.*)

23307. VIGNA UNGUICULATA (L.) Walp. **Cowpea.**

From Peking, Chihli, China. "(No. 933a, Feb. 8, 1908.) Mottled. A rather rare variety, used like No. 950a (S. P. I. No. 23304). Chinese name *Hua chiang doh.*" (*Meyer.*)

23290 to 23312—Continued.

23308. PHASEOLUS VULGARIS L.

From Peking, Chihli, China. "(No. 954a, Feb. 8, 1908.) Lemon-colored beans. A rare variety used as a vegetable in soups. Chinese name *Huang yueng doh.*" (*Meyer.*)

23309. GOSSYPIUM HIRSUTUM L. **Cotton.**

From Pingkuhsien, Chihli, China. "(No. 955a, Nov. 7, 1907.) The ordinary short-fibered variety of cotton grown all over northern China. Chinese name *Ta tse mien hua.*" (*Meyer.*)

23310. GOSSYPIUM INDICUM Lam. **Cotton.**

From Pingkuhsien, Chihli, China. "(No. 956a, Nov. 7, 1907.) A very good variety of cotton, being long fibered and silky. The city of Pingkuhsien is famous throughout North China for the cotton cloth made from this variety. Chinese name *Chan yung mien hua.*" (*Meyer.*)

23311. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Shiling, Chihli, China. "(No. 957a, Jan. 25, 1908.) Large, green soy bean. Used as a vegetable when slightly sprouted, after having been scalded in boiling water. Chinese name *Ta ching doh.*" (*Meyer.*)

23312. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Pautingfu, Chihli, China. "(No. 958a, Jan. 28, 1908.) A rare, local variety of soy bean, being small and of greenish yellow color. Chinese name *Shau ching doh.*" (*Meyer.*)

23313 to 23315.

From Bangalore, British India. Presented by the superintendent of the Mysore Government Botanical Gardens. Received June 25, 1908.

The following seeds:

23313. BAUHINIA MONANDRA Kurz. (?)

"Leaves round-ovate, truncate at base. Racemes short, terminal, pubescent. Petals 1½ inches, probably whitish." (*J. G. Baker, in Fl. Brit. Ind.*)

23314. MANIHOT GLAZIOVII Muell. Arg. **Ceara rubber.**

"Ceara rubber has not been cultivated in the West Indies to any extent, but it is like cassava in its capability of growing in dry, sandy soil. It would probably yield more rubber if grown in districts where irrigation is possible." (*Wm. Fawcett, in Bailey.*)

23315. SAPINDUS TRIFOLIATA L. **Soapnut tree.**

"A stout tree, native of India. Leaves alternate, pinnate. Flowers dull white. Berries the size of a cherry, saponaceous.

"This fruit is used in southern India as a substitute for soap. An oil is also extracted from the berries. The wood is yellow and hard and is used in house building and for combs, boxes, etc." (*G. Watt, Dict. Econ. Prod. Ind.*)

23316 to 23322.

From Guatemala, South America. Collected by Dr. W. A. Kellerman. Received through Dr. J. N. Rose, U. S. National Herbarium, June 25, 1908.

23316 to 23320. **Cactus.**

The following cacti were introduced for investigation as to their possible value for forage:

23316.

From El Rancho. "*Old Man* cactus. (No. 7061, Jan. 12, 1908.) Fruit red, depressed globular, smooth (no prickles), 1½ inches in diameter." (*Kellerman.*)

23317.

From El Rancho. (Kellerman's No. 7055, Jan. 12, 1908.)

23318.

"Cuttings of S. P. I. No. 23317. Very spiny and prickly." (*Young.*)

23319.

From Los Amates. (Kellerman's No. 7107, Feb. 15, 1908.)

23320.

From Antigua. "(No. 7117.) A spineless cactus found climbing over stone fences." (*Kellerman.*)

23321 and 23322. DAHLIA sp. **Dahlia.**

23321.

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23322.

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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 143.
B. T. GALLOWAY, *Chief of Bureau.*

PRINCIPLES AND PRACTICAL METHODS OF CURING TOBACCO.

BY

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PHYSIOLOGIST, TOBACCO INVESTIGATIONS.

ISSUED FEBRUARY 16, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., October 28, 1908.

Sir: I have the honor to transmit herewith a manuscript entitled "Principles and Practical Methods of Curing Tobacco," and recommend that it be published as a bulletin of the series of this Bureau.

The proper management of the curing barn requires some knowledge of the physiological changes which are taking place in the curing process. There is a rapidly increasing demand for such information. For this reason the bulletin has been divided into two parts, one discussing the principles of curing and the second the practical methods of curing based on the principles discussed in the first part.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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PRINCIPLES AND PRACTICAL METHODS OF CURING TOBACCO.

PART I.—PRINCIPLES OF CURING TOBACCO.

INTRODUCTION.

The tobacco plant is very sensitive to the surroundings under which it is forced to grow. Its physical characters, as well as its composition, are greatly influenced by soil, climate, fertilizers, and the treatment which it receives at the hands of the growers. The quality of the finished product, moreover, depends to a large extent on the care and skill which are displayed in the curing and fermentation processes. Again, tobacco is subject to the attacks of numerous insect enemies and to fungous diseases in the seed bed, in the field, in the curing shed, in the packing house, and even after it leaves the hands of the manufacturer. Hence, it will readily be seen that the greatest care and skill must be used by the grower, as well as by the packer and manufacturer, in order to turn out a first-class finished product. There are, in fact, few, if any, other important crops the values of which are so dependent on the painstaking care, skill, and good judgment of the producer. And of the various factors entering into the successful production of a superior quality of tobacco, none is more important than the proper management of the curing process, for a crop of the highest promise may be irretrievably damaged in the curing barn under unfavorable conditions.

The tobacco industry has become highly specialized in this country and has been made the subject of a great deal of study and experimentation on the part of growers; but although the practical side of the industry has attained its highest development in this, its native, country, it has not received anything like the attention the subject merits at the hands of our scientific investigators. This is particularly true of the curing process, for while the process involves many complex changes in the composition and properties of the leaf which greatly affect its commercial value these changes are for the most part imperfectly understood. As a natural result, progress in the development of satisfactory practical methods has been slow, and this phase of the industry is, as a whole, still in a comparatively crude state.

Some of the more important principles of successful curing are well established, however, and it is to the interest of every grower to acquaint himself as far as practicable with the nature of these fundamental facts. Of course, long experience is essential in this as in other features of tobacco growing, but it is also undoubtedly true that the experienced operator will be the better able to meet the various unexpected contingencies which are sure to arise from time to time by carefully studying the underlying principles governing the cure. The more thoroughly the grower understands the nature of the changes going on in the leaf during the curing and the most favorable conditions for bringing about these changes, the easier will it be for him to adopt proper methods for securing these essential conditions. The first portion of this bulletin, therefore, is devoted to a discussion of those changes which take place in the curing process and the most favorable conditions for accomplishing those results. In this discussion the subject-matter has been freed from unnecessary technicalities, so that it is hoped it may be read with interest and profit by the practical grower. It is further hoped that the suggestions made concerning many important phases of the subject which have not as yet been worked out may serve to direct the attention of intelligent and progressive growers to the need of studying further some of these problems. Following this discussion of the subject of curing from the theoretical standpoint will be found a rather complete, though concise, description of the methods now actually in use for curing the various types of leaf produced in the different tobacco sections.

CHANGES IN THE COMPOSITION AND PROPERTIES OF THE LEAF WHICH TAKE PLACE IN THE CURING PROCESS.

If a sample of tobacco taken from the field at the usual time of harvesting were dried out rapidly in an oven and manufactured into appropriate forms for smoking or chewing, it would scarcely be recognized as tobacco by the consumer. Above all else, the grower should keep in mind the fact that curing is not simply the drying out of the leaf but involves a number of other important changes in composition, which can only be brought about under certain definite conditions. There are several different classes of tobacco, each adapted to certain trade requirements, and the details of the curing are variously modified to suit the class to which the finished product is to be assigned. By modifying the conditions of curing, some of the important properties of the leaf are forced to develop along quite different lines. Many of the most valuable qualities of one type may not be at all desirable in another type, so that it is important that the grower first acquaint himself with the trade requirements of the particular type which he can produce to the best advantagé, and then ascertain as nearly as possible the most favorable conditions of curing for developing the fine qualities of that type.

THE RIPENING OF TOBACCO.

Soon after the leaves of the tobacco plant reach maturity they undergo marked changes in color and other properties and these changes constitute the ripening process. The young growing leaf has an intense green color, showing that it is quite rich in the nitrogenous constituents which go to make up the living or vital part of the leaf and which are active in building up the food supply of the plant. At about the time the leaves of the plant as a whole have reached their maximum power of elaborating the food supply the flower head begins to develop. This food supply, consisting of starch and other similar substances, is carried from the leaf into the seed head to furnish the necessary food for the development of the seed. This accomplished, the leaves have completed their full task and they now pass into a period of gradual decay. In practice, however, the plant is topped, so that the seeds are not allowed to develop. Making a last effort to reproduce itself, the plant now sends out secondary shoots or suckers, but these, too, are removed by the grower. Under these circumstances, the food built up by the leaves is not carried away to other parts of the plant but accumulates in the leaves themselves. The result is that both the size and body of the leaf are increased.

The principal indication that the above-mentioned processes are taking place is a decided change of color. When the reserve food supply of the mature leaf is no longer required for the nourishment of other parts of the plant it is deposited in the leaf tissue in the form of starch granules, while the green coloring matters are dissolved and carried to the younger, growing parts. This interchange causes the appearance of the light-tinted flecks so characteristic of the ripe leaf. Moreover, the accumulation of the starch granules in the leaf causes it to become brittle, so that it snaps when folded between the fingers, another characteristic sign of ripeness. Now the replacement of the complex nitrogenous constituents, including the green coloring matter, by the starchy matter has a most important effect on the color, flavor, elasticity, and finish of the leaf. Indeed, much of the success in curing tobacco depends on harvesting it just at the right time, when it is neither too ripe nor too green. Thus, in the case of cigar tobacco, the brightest, clearest, brown colors are obtained when the leaves are harvested just before they would be called fully ripe. If harvested before this period the colors will be dull or "muddy" and too dark, because they still contain too much of the green coloring matters with which the brown coloring substances are closely associated. On the other hand, if the leaves are allowed to become too ripe, the colors will be uneven and mottled and lacking in freshness because of a deficiency of the green coloring matters. For the same reasons a green leaf after curing will be tough and leathery, while an overripe one will be "strawy" and lifeless to the touch. Finally, since the materials which develop the flavor and aroma are derived from the green nitrogenous compounds, the fully ripe leaf will be deficient in these qualities, while the green leaf will possess them much more highly developed.

It is evident, then, that the lower, fully mature leaves of the plant when moderately ripe will be best suited for the production of cigar wrappers bright in color and having the necessary elasticity but neutral in flavor, while the upper leaves harvested before they have fully matured will give the best fillers, having the required flavor and aroma but being much darker in color than the wrappers. In curing the bright yellow tobacco it is necessary that the leaf be fully ripe, for the content of the green coloring matter must be reduced to the minimum consistent with the required toughness in order to obtain the cured leaf free from green or brown discoloration.

CURING THE PICKED LEAVES COMPARED WITH CURING ON THE STALK.

The details of the curing process are variously modified to suit the requirements for the different classes of tobacco, but whatever this subsequent treatment may be there are two general methods of harvesting the crop and arranging it in the barn. In the one case the leaves are picked from the stalk as they ripen and are arranged on strings or sticks suitable for hanging in the curing shed. In the other method the leaves are not removed from the stalks, but the latter are cut off near the ground and suspended in an inverted manner in the barn. Of course all the leaves on the plant do not ripen at the same time, so that the tobacco is harvested at such time as will give the greatest number of the best leaves at the proper stage of ripeness. This necessitates a considerable sacrifice in both bottom and top leaves, since the former are overripe and the latter still immature, but the method saves labor.

There has been much discussion from a practical as well as from a scientific standpoint as to the relative merits of the two methods, and each has its advantages and its disadvantages. Both give satisfactory results when properly carried out, and the question as to which is the better in any given case must be decided largely by the local conditions, such as the amount and kind of the labor supply, the barn space available, and the like. In the end the problem resolves itself into the question of the relative value of the crop to be cured, and nearly all of the highest priced tobaccos are now being cured by the method of picking the leaves, generally spoken of as " priming." This is more expensive than the method of curing on the stalk, but possesses the great advantage that it is possible to harvest all the leaves just at the right stage of maturity, and this fact becomes important when the tobacco is produced under a highly intensive system involving a large outlay of capital.

Although, as has been said, both methods are capable of giving good results, there are undoubtedly differences in the character of the cured product as obtained in the two processes. To understand the differences brought about by these two methods of curing, we must remember that the leaves and the stalks remain alive for several days or even weeks after harvesting, depending on the conditions which prevail in the curing barn. They are enabled to remain alive so long as they retain sufficient moisture by means of the reserve food supply which has been stored up. The outer edges of the leaf are first killed by loss of moisture, and the unused portion of the food supply is withdrawn toward the midrib, which is the last part of the leaf to die. When the leaves are picked from the stalk, of course this transfer of the food materials can get no farther than the midrib of the leaf, but when the leaf remains attached to the stalk these food materials pass into the stalk to keep this alive and to supply nourishment to the young suckers which are struggling to develop.

Every one who has cured cigar tobacco on the stalk must have been impressed by the remarkable vitality of the stalk itself as well as of the young suckers, whereby they remain alive for many weeks before the point of starvation is reached. On account of the water contained in the stalk, which gradually passes into the leaf to replace that lost by evaporation, the leaf under these conditions remains alive for a much longer period than when separated from the stalk. Since a portion of the reserve food supply of the leaf is transported into the stalk when the leaf is left attached to the stalk, and since, further, the leaf remains alive for a longer period under these circumstances, and so itself uses up more of its accumulated food, we should not be surprised that leaves cured under these conditions are considerably lighter in weight than those cured after being separated from the stalk. The most careful experiments on this point have shown that picked leaves are about 11 per cent heavier after curing than those cured on the stalk. It has also been found that when suckers are left on the stalk at the time of harvesting there is a still greater loss in weight by curing the entire plant. We have very little accurate information as to the relative effects of the two methods of curing on the quality of the leaf, but, other things being equal, it is probable that the picked leaves will have more of the so-called "gum" and more body than those cured on the stalk.

In the case of the yellow tobacco, the curing on the stalk is modified in that the stalk is split open for almost its entire length. This class of tobacco, furthermore, is all cured by artificial heat, and both of these circumstances, of course, operate to greatly shorten the life of the stalk after it is placed in the barn. Hence there is little opportunity for the transportation of material from the leaf into the stalk. But here again curing on the stalk serves to keep the leaves living for a longer period than is the case when they are picked. This class of tobacco is very rich in starchy matters, and while these may not be transported into the stalk they would be more completely consumed by the leaves themselves when cured on the stalk. This naturally gives a tougher leaf, possessing relatively more gummy or resinous matter. At any rate, it is commonly believed by growers in the older yellow-tobacco districts that the best plug wrappers can only be obtained by curing the leaf on the stalk. Nevertheless, a good grade of wrapper is obtained in the newer districts of the yellow-tobacco belt by picking the leaves for curing.

THE AIR-CURING PROCESS.

Apart from the two different methods of harvesting and hanging the tobacco in the barn, the method of conducting the curing process is variously modified according to the uses for which the leaf is intended. These differences in procedure pertain chiefly to the rate of drying out of the leaf, and this in turn is controlled mainly by the use of artificial heat. The character of the cured product is greatly modified by these different methods of procedure, and it is necessary to consider separately the types cured with and those cured without the aid of artificial heat. In the latter case the process is known as air-curing and a large proportion of our finest tobaccos is cured by this method.

Practically all of the cigar tobaccos wherever produced and the immense quantities of Burley tobacco grown in Kentucky and adjoining States are cured without the use of artificial heat except during a siege of very wet weather. The tobacco is placed in the barn in the green state, usually after having been wilted, and the subsequent curing is controlled simply by opening or closing the ventilators as occasion demands. In considering the changes taking place in the leaf during the curing process, this may be divided into two periods, during the first of which the leaf remains alive, while in the second the changes which occur have no connection with its life activities.

FIRST STAGE OF AIR-CURING.

The changes which occur during the first period of the curing, and which are by far the most important, are dependent upon the life activities of the minute cells which make up the body of the leaf. If a ripe tobacco leaf is killed outright with chloroform or with heat and then placed under normal curing conditions, it does not develop the characteristic properties of a well-cured leaf. It is certain, therefore, that in order to secure a satisfactory cure the conditions must be such that the leaf will remain alive long enough to allow these necessary changes to take place. In the curing shed the leaf undergoes a slow process of starvation unless it is killed prematurely by injury, such as bruising, by heat, or by too rapid drying out. Of course, the leaf must have food in order to remain alive, and this comes from the reserve supply which has been stored up.

We have seen that the ripe leaf is very rich in starch and that one of the important changes in the curing is the disappearance of this starch, which is consumed by the living portion of the leaf itself. Now, if the leaf is killed by bruising, rapid drying, or heating too high there is no means of removing this starch, and the tobacco is harsh, lifeless, and "strawy." The vitality of the tobacco plant is remarkable, and parts of the leaf will continue to live for several weeks in the curing barn under favorable conditions. After the starch is all used up it is probable that some of the nitrogenous constituents are attacked as a last means of prolonging the life of the residual living matter.

Along with these changes in composition the green color is replaced by a lemon-yellow. This change from green to yellow takes place in all tobacco, whatever the method of curing may be, if it is properly conducted. The green coloring matter of the tobacco leaf, called chlorophyll, is found in all green plants in very similar, but not identical, forms. During the period in which the leaf tissue is undergoing starvation, this green coloring matter is more or less completely changed into colorless substances, and the appearance of the yellow color marks the approaching death of the leaf. If the green leaf is killed outright soon after harvesting by bruising or rapid drying out, the green color can not be removed by any subsequent treatment the leaf may receive; but if the leaf remains alive for two or three days, even though the green color has not fully disappeared, that which remains may be removed by sweating or fermentation.

It must not be thought that the yellow coloring matter is formed during the curing process directly from the green coloring material. This yellow coloring matter is contained in the green leaf before it is harvested and also after it has turned brown. The yellow is simply obscured in these cases by the more intense green or brown. In fact, the yellow becomes apparent in the overripe plants in the field, and when the brown coloring matters are deficient it may still be visible after the leaf has been fermented. It is interesting to note that the green color is never entirely destroyed in the inner parts of the leaf, even after fermentation followed by a long period of aging.

SECOND STAGE OF AIR-CURING.

The full development of the yellow color marks the end of the first period of the curing. In the second period the changes which take place are not dependent on life processes, and hence can be accomplished in the fermentation bulk as well as in the curing barn. The fermentation is, in fact, merely a continuation of the second stage of the curing. The changes taking place in this case are for the most part quite different from those occurring in the first stage of the cure. After the leaf is dead, no more of the starch is consumed, nor are the protein nitrogenous compounds attacked. The changes consist mainly in the further breaking up of the products formed in the first stage of the curing. One of the most important changes is the development of the brown color. Here again it must be understood that the brown coloring matters are not derived from the yellow, nor are they derived directly from the green coloring material. They are formed by a process of oxidation which does not take place till the cells of the leaf are dead. As soon, therefore, as portions of the leaf die they at once begin to turn brown, provided sufficient moisture is present. The two essentials for the development of the brown color are a supply of oxygen, which is obtained from the air, and a sufficient amount of moisture. This development of the brown color, which is begun in the second stage of curing, is always completed in the fermentation of the tobacco, and the chief danger as regards the curing is that the development will proceed too far because of excessive moisture, causing the leaf to cure too dark. The amount of coloring matters in the leaf probably depends chiefly on the conditions as to soil, fertilizers, and climate under which the plant is grown, and so is not under the control of the operator in the curing. But the depth of the brown color is governed by the extent to which the oxidation is allowed to proceed, and this factor can be controlled by regulating the moisture supply.

It has been explained how the important changes in the first stage of the cure can only be effected by keeping the leaf alive for a sufficient period of time and that once the leaf has been killed these changes can not be accomplished by any subsequent treatment. On the other hand, those changes occurring in the second stage of the curing take place after the leaf is dead and are largely continued in the subsequent fermentation. The extent of these changes is governed by the external conditions of temperature, moisture, light, and air supply. It is quite impossible to control these conditions properly in the curing shed, whereas they can be readily managed in the sweat room. It is therefore desirable to complete the second stage of the cure as rapidly as practicable and then to keep the tobacco comparatively dry until it is ready for fermentation. A great deal of air-cured tobacco, especially of the cigar types, is seriously injured in quality every year because of the damp or cold weather encountered during the last stage of the curing and in the interim before the tobacco is removed from the barn. These unfavorable weather conditions greatly prolong the final drying out of the leaf and cause a sort of cold sweat to take place, which prevents a normal sweat in the pack-house. It is a common experience among packers to find that tobacco cured under these conditions will not heat up properly in the bulk.

As regards quantity, the most important change in the curing is the loss of water. The tobacco leaf normally loses about 75 per cent of its green weight in the curing, and by far the greater portion of this loss is water. Thus it has been found that 8,000 plants grown on an acre of ground in the Connecticut Valley and yielding about 1,800 pounds of cured leaf weigh when harvested something like 8 tons, of which fully 6 tons are water. To cure tobacco successfully this vast amount of water must be removed under such conditions and at such rate as will best allow the other important changes to take place.

THE MOST FAVORABLE CONDITIONS FOR AIR-CURING.

The question now arises as to the most favorable conditions for air-curing and the means of controlling these conditions. It has been shown that the principal changes taking place in the first stage of curing are due directly to the activities of the living cells while they are passing through a period of gradual starvation; hence, the conditions should be such as are most favorable to these activities. These cells are killed by bruising, so that it is important to avoid injury in this way in the harvesting as far as possible. Again, these cells are killed by excessively low or high temperatures and by the rapid loss of water. The life activities of the tobacco plant practically cease at temperatures below 40° F., while they increase as the temperature rises, until at about 125° F. the living cells are rapidly killed. These activities are also greatly lessened by loss of water and cease as soon as the leaf becomes dry. In practice, the most favorable temperatures for curing lie between the limits of 60° and 100° F., and the relative humidity should be about 85 per cent. Under these conditions the leaf will gradually lose its water, but will never be out of case or order and the curing will proceed smoothly. If the humidity becomes much higher, pole-sweat will develop on the leaves most advanced in the curing, while if the humidity falls much below this figure the leaf will dry out too rapidly.

In the second stage of the curing, when the leaf begins to turn brown, there is no longer any need for keeping the air in the barn so moist, and the relative humidity may be lowered to about 80 per cent, and later still further reduced to 65 or 70 per cent, until the stems are dry. It is desirable to prevent the tobacco from coming into high case after curing until it is to be taken down, and it should be stripped and packed as soon as possible after the curing is completed. So long as artificial heat is not used the temperature will never become too high for favorable curing, but it frequently becomes so low as to seriously interfere with the process.

Unfortunately the growers at the present time have very limited means of controlling the temperature and relative humidity in the barn in the air-curing process. It is indeed a remarkable fact that the methods employed in this process are the crudest of all those used in curing tobacco, for the operator is almost at the mercy of the weather conditions. If the season is too dry, the tobacco "hays down"—that is, simply dries out like hay—while if it is too wet, the tobacco is seriously damaged by pole-sweat. Of course marked advances have been made in this method of curing in recent years, but these improvements consist chiefly in the construction of better barns, which is only one step in the right direction. It remains for some one to work out a practical method of controlling the temperature and humidity in the barn when the weather conditions are unfavorable. Many thousands of dollars' damage to the tobacco crop results annually from lack of means for maintaining the proper conditions in the barn during the curing period, and this loss can never be overcome until satisfactory means are provided for conducting the cure independently of outside weather conditions.

All experienced tobacco growers are aware of the serious damage likely to result from pole-sweat during the periods of very wet weather, but few of them appear to fully appreciate the extent of the injury in quality caused by the opposite extreme of excessively dry weather. This fact is probably due to the circumstance that injury by pole-sweat is of such a character that it is promptly recognized, since the tissues of the leaf are actually disintegrated, while, on the other hand, tobacco which has been dried out too rapidly is perfectly sound, and its inferior quality is not fully apparent until after it has been fermented, when it is likely to be attributed to other causes. Although in this case the value of the leaf is never entirely destroyed, the damage is more widespread and of more frequent occurrence, so that in the aggregate it probably amounts to more than that caused by pole-sweat. The average grower, in his anxiety to avoid pole-sweat, is apt to hasten the first stage of the cure far too rapidly to secure the best results.

POLE-SWEAT, OR HOUSE-BURN.

This disease, which is especially to be dreaded during periods of prolonged wet weather accompanied by relatively high temperatures, occurs the world over where tobacco is cured without the use of heat. It is caused by some of the lower organisms which attack those constituents of the leaf which give it toughness and stiffness. As a result, the tissues soften and lose their coherency, so that the leaf simply falls apart. These organisms are not true parasites—that is, they do not attack living matter—so that pole-sweat can not occur until after the leaf tissue dies. But of course some parts of the leaf may die much sooner than others, so that pole-sweat may appear before the entire leaf is dead. Naturally, it first attacks those leaves which have been bruised or broken in harvesting. Again, it appears first on the lower leaves of the plant, which die more rapidly than the upper, greener leaves. Its development is greatly favored by crowding the plants or the leaves too closely, thus preventing the necessary ventilation.

The organisms which cause this trouble are not active at very low temperatures, so that pole-burn does not appear to any extent in cold weather. Furthermore, they only thrive in the presence of an abundance of moisture. The three essential conditions for the rapid spread of the disease, then, are: (1) Tobacco which has passed through the first stage of the cure or which has been killed by bruising or other injury; (2) a temperature ranging from 60° to 100° F.; and (3) a relative humidity of 90 per cent or more, which checks the evaporation from the leaves, causing them to become soggy. Under these conditions it is amazing to note the rapidity with which the trouble spreads throughout the barn. Of course, conditions favorable to pole-sweat may exist for short periods without the appearance of the disease, but it will certainly develop if these conditions continue from twenty-four to forty-eight hours.

True pole-sweat implies more or less decay of leaf tissue, but the leaf may be discolored without materially affecting its soundness. This is caused by short periods of excessive humidity which do not continue long enough for the development of the organisms which attack the leaf structure. In this case dark-colored oily drops collect on the surface of the leaf, especially at the tips, and when these evaporate dark spots are left. Such spotted leaves are almost worthless for bright wrappers, although the tissue is perfectly sound.

There is no doubt that the remedy for this disease lies in controlling the humidity in the curing barn during periods of excessively damp weather, but so far no cheap practical method of accomplishing this has been devised. It is believed by some growers that ventilation affords protection, but if the relative humidity outside of the barn is above 90 per cent, ventilation alone can not possibly do any good. The whole problem lies in keeping down the humidity, and the only practical method of doing this consists in the combined use of heat and ventilation. Various means of introducing heat into the barns during unfavorable weather conditions have been tried, and some of these have been successful under certain conditions. We have seen that either excessive dryness or excessive moisture in the barn during the curing process will seriously injure the value of the tobacco. Where the color of the product is of importance, injury will result from excessive humidity whether or not pole-sweat appears. The control of this disease is therefore merely one phase of the more general problem of maintaining in the barn the most favorable conditions for the development of the finest qualities in the leaf.

AIR-CURING AS AFFECTED BY HEAT AND VENTILATION.

One of the pressing needs at the present time in the production of air-cured tobacco is some adequate means of controlling the temperature and humidity in the curing barn whereby the process can be conducted more or less independently of the outside weather conditions. With the hope of stimulating interest in this problem among growers, some of the fundamental principles which must be made use of in any practical solution are briefly stated in the following paragraphs.

Tobacco as it is hung in the barn contains an enormous amount of water which must be removed by evaporation from the surface of the leaves and at such rate as will allow certain important changes in composition to take place. So long as the minute cells of the leaf remain alive they resist the loss of water, so that it is only given up slowly unless the surrounding air is quite dry. On the other hand, as soon as the cells are dead, marking the end of the first stage in the curing, the remaining water is set free and will ooze out to the surface of the leaf whether or not the surrounding air be dry.

Accordingly, the first stage of the cure can be prolonged as far as is necessary by keeping the surrounding air moist, while in the second stage the water must be removed as fast as it comes to the surface of the leaf by keeping the air sufficiently dry if we are to avoid injury from pole-sweat or discoloration. At the time the tobacco is hung in the barn, water is evaporating from the surface of the leaves, and this evaporation continues until the surrounding air is saturated with moisture. A given volume of air, or, more correctly, the space containing this air, is capable of taking up a certain amount of moisture and no more at any particular temperature. Hence, the evaporation from the fresh tobacco leaves will soon cease unless the surrounding air which has become saturated is replaced by a fresh supply of drier air. In other words, we must have ventilation.

Contrary to the general impression, moist air is lighter than dry air at the same temperature, and consequently the saturated air in the barn will tend to rise to the top, while the heavier, drier air will flow in from the outside to replace it. Again, warm air is lighter than cold air and will rise, so that when the sun shines on the roof of the barn, thus warming up the upper sections of the inclosed air, this warmed air is forced upward by the cooler, heavier air near the ground. For these reasons the natural course of ventilation in the curing barn is for the cooler, drier air to enter the barn near the bottom, pass upward through the tobacco, thus absorbing more moisture and becoming warmer, thereby growing constantly lighter, and finally to pass out of the top of the barn. Of course, if the wind be blowing briskly the air may be driven directly through the barn when ventilators are opened on the sides, thus providing a sort of forced ventilation.

In moderately dry weather it will be seen that ventilation is all that is needed to secure favorable curing conditions, provided the temperature is not too low, but that ventilators should be provided at the top of the barn as well as on the sides. In very dry weather the evaporation from the leaves should be kept in check by having the barn built as tight as possible and by keeping all ventilators closed during the day. In this case it is well to open up the ventilators during the night in order to insure plenty of fresh air in the barn. Unfortunately this precaution against injury from dry weather can not be satisfactorily observed under present conditions, owing to the danger of pole-burn which would be incurred in case a prolonged season of wet weather should follow. Yet there is no doubt that many growers allow their tobacco to dry out too rapidly by opening all ventilators on dry days.

While the rate of curing can be satisfactorily controlled when the weather conditions are just right or when it is too dry by proper management of the ventilation, it is quite different in either cold or very wet weather. If the temperature is low, the curing changes are stopped, although the tobacco may continue to dry out. In this case the leaf is simply dried and not cured. During rainy or foggy weather the air is practically saturated with moisture, and since it can not take up any more it is obvious that ventilation alone is useless under these circumstances. Now, the capacity of the air for water vapor is greatly influenced by the temperature; thus, at 52° F. a cubic foot of saturated air contains 0.00063 pound of water vapor, while at 72° F. the capacity is increased to 0.00122 pound. By raising the temperature of the air 20 degrees we double its capacity for holding moisture. It is obvious, therefore, that if air which is saturated with moisture enters the barn and if its temperature is raised 20 degrees the relative humidity drops from 100 per cent to 50 per cent, or the air becomes about as dry as on an average bright, sunshiny day. Given some suitable means of maintaining the temperature in the barn from 15 to 20 degrees higher than that of the outside air, combined with proper ventilation, the problem of controlling the curing conditions would be solved.

If the air becomes saturated at any given temperature, any lowering of this temperature will cause some of the moisture to be deposited in the form of liquid. This is why pole-sweat progresses so rapidly when moderate temperatures are followed suddenly by warm, wet weather, for the warm, saturated air from the outside coming in contact with the cooler tobacco is chilled and actually deposits moisture on the leaf. For the same reason an insufficient quantity of heat is worse than none, for the temporarily warmed air absorbs more moisture from the tobacco in the lower part of the barn, but is cooled before it reaches the top and deposits this moisture on the tobacco in the upper part of the barn. Consequently, enough heat must be supplied to warm the barn up to the top and thus drive out the moist air.

AVAILABLE METHODS OF APPLYING ARTIFICIAL HEAT.

One of the first essentials is that the heat be produced at the bottom of the barn and properly distributed so that in rising it will be forced to pass through all portions of the tobacco. Otherwise local currents will be set up, while a large portion of the air remains stagnant. Herein lies the great objection to the open fires which are sometimes resorted to. It is impossible to avoid overheating the tobacco hanging directly over the fires, while that between the fires does not receive enough heat. Obviously the greater the number of fires the more satisfactory will the result be. This method of applying heat has been successfully used in sections where the leaves are picked from the stalk before curing, but when the leaves are cured on the stalk it has not been found satisfactory. In addition to the uneven distribution of the heat and the difficulty of maintaining anything like a uniform temperature a considerable amount of space in the barn must be sacrificed, for in hanging the tobacco at least a part of the lower tier must be left vacant. At best it is only a means of warding off pole-sweat and does not reach the broader problem of maintaining the proper curing conditions in the barn at all times.

Steam as a source of heat presents many obvious advantages. This is apparently the only means of heating whereby the temperature can be distributed uniformly and readily controlled. Of course the first cost of installing a steam-heating system would be considerable, but it would last indefinitely. With a system of this kind the curing could be carried out independently of the weather conditions. In considering the cost and value of any system of heating it should be remembered that protection against pole-sweat is by no means the only object to be sought. It rarely happens that the most favorable conditions of temperature and humidity prevail during the curing season, and there can be no doubt that the value of the crop would be materially increased by the judicious use of a steam-heating system. The practical question is whether the increase in the quality of the leaf would be sufficient to warrant the use of this system.

Recent experiments with a system of flues for supplying heat similar to those employed in curing yellow tobacco have given promising results. Here, again, the principal difficulty to be overcome lies in the proper distribution of the heat. The barns used in the flue-curing districts are not more than 24 feet square, so that the flues are never more than 6 or 8 feet apart. It will be seen that a large number of flues, with a corresponding number of furnaces, would be required for the barns in the air-curing districts. It would scarcely be practicable to set these flues up in permanent form, so that it would be necessary to take them down before putting in the tobacco and before taking it down again after curing. It is not a difficult matter, however, to set up the flues, and they may prove to be the practicable mean between the ideal but costly steam-heating system on the one hand and the unsatisfactory method of using open fires on the other.

MODIFICATIONS OF THE AIR-CURING PROCESS.

The air-curing has been discussed mainly from the standpoint of cigar tobaccos, but the same principles apply to other types, more particularly the Burley tobaccos. The changes which take place in the first stage of the cure are of the same character, but the final color changes are somewhat different. Instead of the characteristic brown of the cigar leaf the Burley should have a golden red color after curing. In each case, however, the brightest colored leaf commands the highest price, so that Burley tobacco, like the cigar leaf, should not be exposed to excessive moisture in the last stages of the cure.

In a few counties of Virginia a type of plug tobacco is produced which is known as " sun-cured tobacco." The tobacco is hung on scaffolds, exposed to the sun for several days, and then transferred to the barn, where the curing is completed without the use of artificial heat. This method of curing has not been investigated, and practically nothing is known of the differences in composition between sun-cured and ordinary air-cured tobaccos.

THE FLUE-CURING PROCESS.

The distinctive feature of the flue method of curing is that the barn is provided with a system of large pipes through which the heated air is passed throughout the curing period. The smoke does not come into contact with the tobacco and the cure is completed within a few days. One of the principal factors controlling the value of the leaf cured by this method is the color, and the two prime conditions for success in this respect are the right kind of soil and the proper control of the curing. The color most desired is a characteristic bright lemon-yellow, and, in addition, the leaf should have sufficient gummy matter to give it flexibility, but it must also be of a spongy character, so that it will absorb large quantities of the sauces used in manufacturing chewing tobacco.

CHANGES IN THE COMPOSITION AND PROPERTIES OF THE LEAF.

In the flue-curing method, just as in the air-curing process, the principal changes in composition brought about in the curing are dependent on the life activities of the minute cells in the leaf, and the nature of the changes in the two methods is the same. The main difference lies in the extent or completeness of these changes. The typical bright yellow tobacco at the time of harvesting is riper than most tobaccos cured without the use of heat. Partly on this account, and also because of the character of the soil on which it is grown, this type of leaf is relatively richer in starchy matter and poorer in organic nitrogenous materials, particularly the coloring matters.

Because of the difference in composition, combined with the effects of higher temperatures and more rapid drying, the green color is removed much more rapidly. It is to be remembered that here, as in all other types of tobacco, the yellow color is not formed directly from the green, but is already present in the green leaf. The rapid appearance of the yellow color does not afford sufficient time for the transformation of all the starchy matter, and as soon as this stage is reached the drying must be hastened so as to prevent any further change in color. Evidently, then, the flue-curing method consists essentially in the hastening and shortening of the first stage in the air-curing process, while the second stage of the cure, made apparent by the development of the brown color in the case of cigar tobaccos, is not allowed to take place at all.

CONDITIONS AFFECTING THE RATE OF CURE.

It is interesting to note the large number of formulas or rules which are in use in curing this type of tobacco, any of which will give satisfactory results in certain cases. This is due partly to differences in the tobacco when harvested and partly to the fact that all of these formulas are based simply on the temperature in the barn, with scarcely any reference to the humidity, which is really the controlling factor in the rate of curing. The principal function of the artificial heat is to regulate the humidity, and obviously this is also dependent on the amount of water in the tobacco and on the prevailing weather conditions.

The capacity of the air for holding moisture, and consequently its drying capacity, depends principally on its temperature, and air which is already saturated has no drying power until its temperature is raised. Satisfactory curing can only be accomplished by proper regulation of the rate of drying, and this depends chiefly on the humidity of the air in the barn. From these facts it is clear that in order to maintain a definite rate of drying by controlling the humidity, the temperature in the barn must bear a certain relation to that of the outside air, and the difference in temperature inside and outside the barn will be influenced by the humidity of the outside air. In warm weather the temperature inside the barn must be higher than in cool weather, and in rainy or in foggy seasons it must be higher than in clear, dry weather.

In addition to temperature there is another equally important factor in controlling the humidity in the barn, and consequently the rate of drying, and this is ventilation. If the barn were perfectly tight, the air within would of course soon become saturated, and the inevitable result would be that the tobacco would sweat; that is, drops of water would collect on the surface of the leaves. The warm saturated air in the barn must therefore be constantly replaced by the cooler, less humid outside air, and hence proper means of ventilation should be provided. It is astonishing to note the small number of growers who fully appreciate the importance of ventilation. Most barns are built without any provision for ventilation, and the only reason that curing can be successfully done in these cases is that the barns are not sufficiently tight to prevent the natural ventilation caused by the higher temperatures within. Frequently this natural ventilation is insufficient, and at the critical moment the tobacco is irreparably damaged by discoloration because of lack of means of ventilating the barn to remove the excessive moisture. On the other hand, there are times when it is desirable to check the rate of drying, so that it is important to provide ventilators at the top and bottom of the barn which can readily be closed when occasion demands.

MANAGEMENT OF FLUE-CURING.

The completion of the curing proper is marked by the development of the yellow color. This transformation from a green to a yellow color, along with other attendant changes, takes place while the leaf is still living, and if the leaf is quickly killed by heat or by being rapidly dried it will be impossible to remove the green color. At temperatures above 125° F. the leaf is rapidly killed, so that this limit must not be exceeded during the yellowing process. The greatest danger in this first stage of the curing, however, is that the leaf will dry out so rapidly as to prematurely kill it. After the leaf is dry no amount of heat can remove the green color. The yellowing process may be accomplished at any temperature ranging between 80° and 120° F., provided the humidity in the barn be properly managed.

Care must be taken to avoid drying the leaf too rapidly during the first stage of the cure, but as it begins to yellow the humidity in the barn must be materially decreased by slowly raising the temperature and gradually increasing the ventilation. If these two points are carefully observed there will be little trouble from so-called "sponging" or "scalding." As soon as the leaf has become yellow the whole problem is to regulate the drying so as to prevent any further change in color. This second stage of the curing, known as "fixing the color," is the critical period and requires the closest attention. There are two fundamental facts of the greatest importance in this connection, namely, that the brown or red color can not appear until the leaf is killed and that it develops only in the presence of considerable moisture.

The appearance of the yellow color indicates that the leaf has reached the dying stage, but it still contains a large amount of water. When the leaf tissue dies all the moisture within the leaf is released and will rapidly move to the surface, so that unless this moisture is promptly removed the leaf will certainly begin to turn a reddish brown color. To avoid this injury to the tobacco the heat must be raised very slowly, so as to kill the leaf tissue gradually, and, more important still, plenty of ventilation must be provided to take away the moisture. The temperature should not be allowed to fall during this period.

In addition to this reddening of the leaf, commonly called "sponging," which is caused by failure to remove the moisture by sufficient ventilation, there is often trouble from a somewhat different discoloration, known as "scalding," or "splotching." The primary cause of this is advancing the temperature too rapidly while the leaf still contains much moisture. The rapid increase in temperature kills the leaf cells so rapidly that the water which is set free brings to the surface of the leaf some of the coloring matters from within, and the result is a bluish black discoloration.

CURING TOBACCO WITH OPEN FIRES.

In the districts where heavy shipping tobacco is grown the so-called "fire-curing" is almost universally employed. This method is really a sort of combination of the air-curing and flue-curing processes, differing from the former in that artificial heat is invariably applied in the later stages and from the latter in that the heat is applied by means of small open fires. The first stage of the cure is identical with the ordinary air-curing, and the changes which take place are of the same character. After the tobacco has been curing for four or five days, either on scaffolds in the field or in the barn, small fires are started and only very moderate temperatures maintained for about twenty-four hours. After this the temperature may be considerably increased. When the leaf and half the stem are cured the fires are withdrawn and the tobacco allowed to soften up again, after which the fires are again started.

The tobacco in the fire-curing districts is characterized by an extremely thick, heavy leaf, very rich in nitrogenous matters, and hence it cures very slowly. Before the fires are started the greater portion of the starch has been used up, and this change is necessary to give the leaf the required flexibility. The low heat which is then applied is necessary to hasten the curing, particularly the removal of the green color, and to reduce the moisture in the leaf so as to prevent blistering or splotching when the temperature is advanced. The application of heat to this tobacco as soon as harvested would not afford sufficient time for the curing changes to develop before the leaf became dry. On the other hand, if the removal of the green color were not hastened by the use of artificial heat the time required for this change would be so long as to cause the appearance of the reddish brown color.

Tobacco cured by this process is exposed directly to the smoke from the open fires, and consequently acquires a characteristic flavor and odor. The substances of a creosotic nature absorbed from the smoke have marked antiseptic properties and prevent the leaf from suffering injury in shipment to foreign countries.

PART II.—PRACTICAL METHODS OF CURING AS APPLIED TO THE VARIOUS TYPES OF TOBACCO.

CIGAR TOBACCOS.

To a certain extent every tobacco plant produces the three components of the cigar, the upper leaves being used for the filler, while the lower ones furnish the binder and wrapper. In practice, however, the soil and climatic conditions of the different cigar-tobacco districts do not produce these three grades of leaf to the same degree of excellence, so that these districts are generally classified according to the particular grade of leaf they produce to the best advantage. Thus, the light, sandy soils of the Connecticut Valley produce a thin, fine-textured leaf especially adapted for wrappers but lacking in the flavor and aroma essential for filler purposes, whereas the heavy soils of Ohio produce a heavy leaf poorly suited for wrappers but prized as a filler because of its characteristic flavor and aroma.

The bulk of the cigar-tobacco crop at the present time is grown in the States of Massachusetts, Connecticut, New York, Pennsylvania, Wisconsin, Ohio, Florida, Georgia, and Texas. The finest grades of wrapper leaf are grown in a few counties of western Florida, southern Georgia, eastern Texas, and in the Connecticut Valley, while Wisconsin is known as a binder State and New York, Pennsylvania, and Ohio produce mainly filler grades. All cigar tobaccos are cured without the use of artificial heat, and the general methods of procedure are essentially the same in all the cigar-tobacco-growing States except in the case of the shade-grown types of Florida and Connecticut. The methods of harvesting and curing this type of leaf differ sufficiently from those commonly in use to warrant special consideration.

CONSTRUCTION OF THE BARN FOR CURING CIGAR TOBACCO.

Great advances have been made in recent years in the construction of barns for curing cigar tobacco, and many of those now in use are well adapted to this purpose. The main improvements have been in building the barns more nearly weatherproof and in providing more efficient means of ventilation. In some sections there has been a marked tendency to increase the size of the barns, so that now it is not unusual to find them 300 feet or more in length. The chief consideration in this increase of size has been one of economy in construction, but it is undoubtedly true that the best barn is the cheapest in the end, so that the deciding question should be whether the larger barn is better adapted to controlling the curing conditions. So long as the grower is dependent on outside weather conditions in curing his tobacco the danger from pole-sweat will be greater in the larger barn, because of the increased difficulty in maintaining the necessary ventilation, so that any gain in economy of construction is likely to be more than offset by this danger.

In building a good barn the two principal considerations to be kept in mind are to construct it as nearly air-tight as possible and at the same time to provide an efficient system of ventilation, for in the absence of any method of supplying artificial heat these constitute the only means of controlling curing conditions. A site should be chosen for the barn which is thoroughly drained and sufficiently removed from other buildings to allow free access of air. It should be as near the tobacco field as possible, for convenience in harvesting. A convenient width for the barn is 32 feet, while the length should be some multiple of 16 feet if the tier poles, which are 16 feet long, are to run lengthwise of the building. Many barns are built 4 tiers high, but the curing can be better controlled when the building is only 3 tiers high to the plate. The tobacco should not hang within 3 feet of the ground, so that the first tier of poles should be at least 8 feet from the ground and the remaining tiers 5 feet apart. Thus, a barn 3 tiers high will be 18 feet to the plate, or one 4 tiers high will be 23 feet to the plate. The sills for the frame should be raised at least a foot above the ground, resting on brick or stone piers. The roof is given a steep pitch and generally carries two additional tiers for hanging tobacco, the lower being composed of 4 rows and the upper of 2 rows.

The posts, plates, and beams used for the frame should not be less than 7 by 7 inches. At intervals of 16 feet posts, frames, and girders are set up across the barn the same as at the ends, thus dividing the frame into 16-foot sections, known as "bents." The importance of building the frame of stout, substantial timbers can be appreciated when it is remembered that each bent of the dimensions stated above is capable of holding 4,500 plants, which in the green state will weigh at least 20,000 pounds. The girders on the ends and on the bents for carrying the lower tier of poles should be made removable, while those for the two upper tiers should be well braced. The tier poles on which the tobacco is hung are 16 feet long and may be sawed out, though round poles serve just as well. They must be stout enough to carry 800 pounds.

The boards for the sides and ends should be of first-class quality, lined, and of uniform width. All cracks should be battened with thin strips about 3 inches wide, so as to make the structure as nearly weatherproof as possible. At least every third board should be hung on hinges as a ventilator. The boards may be put on either vertically or horizontally, and there are numerous ways of arranging the ventilators. If the boards are put on horizontally those used for ventilators are hinged from the upper edge and are generally tied together by vertical strips, so that all of them may be operated from the ground. When the siding is put on vertically those boards used for ventilators may be hinged either from the top or side, and in the former case are also usually tied together. In any case the ventilators on the sides should extend nearly up to the eaves and those on the ends should be extended to the roof. There are some desirable features in all of these methods of ventilating, but the vertical system of ventilators hinged at the top is more in accord with scientific principles and possesses a number of advantages over the others. These ventilators furnish better protection from the direct sunlight and from the wind, while they always afford the largest opening for admission of air near the bottom, which is desirable since natural circulation is always upward. Extending along the entire length of the sides, a horizontal ventilator should be provided at the bottom for admitting air below the sills. Comparatively few barns at the

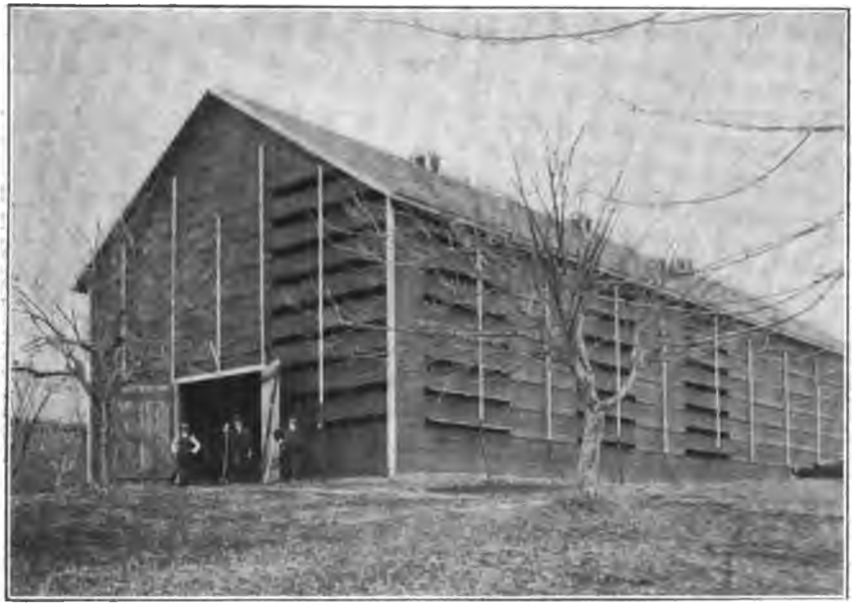

FIG. 1.—Type of barn used in northern cigar-tobacco districts, showing the arrangement of horizontal ventilators.

present time have any provision for ventilation on the roof, but any method of controlling pole-sweat in wet weather by the use of artificial heat will require some means of providing for the escape of the moisture-laden air at the top of the barn.

A barn 32 feet wide should have two driveways extending all the way through the building, and doors should be provided at each end of sufficient size to allow a team to be driven in or out without difficulty. Some barns have a greater width, thus affording room for three driveways. Again, in some cases, doors are provided on the sides opening into each bent, but this arrangement is not recommended, for it greatly increases the difficulty of rendering the structure weatherproof. The construction of barns used for curing cigar leaf in the southern districts is essentially the same as that of the barns in northern districts, except that the ventilators usually consist of windows at intervals of about 8 feet, 2½ to 3 feet wide and 10 feet long, suspended at or near the top. A good type of barn fitted with a system of horizontal ventilators, which is used in northern districts, is shown in figure 1, while figure 2 shows the typical barn in use in the southern districts.

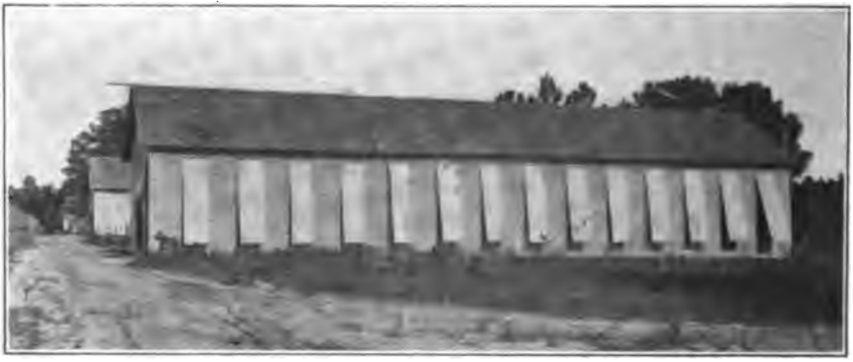

FIG. 2.—Type of barn used in southern cigar-tobacco districts, showing the arrangement of ventilators.

HARVESTING CIGAR TOBACCO.

In two or three weeks after topping, the plants will begin to ripen, as indicated by a change in color of the leaf. Light yellowish green flecks appear on the surface of the leaf and it snaps readily when folded back. To know just when the plants are ready for harvesting requires experience and good judgment, and much of the success in curing will depend on this point. Of course, all the plants do not ripen at exactly the same time, but usually in harvesting no attempt is made to single out the riper ones unless these occur in well-defined areas in the field. Cutting cigar tobacco in the northern districts usually begins about the middle of August and extends through the month of September, but the time may vary as much as three weeks in different years, depending on the season.

The stalks are cut with a variety of implements, among which are stout knives with hooked blades, an ordinary hatchet, a handsaw, or shears with long handles. The hatchet and shears are more commonly used, and the latter are becoming quite popular. The handles are of such length that the largest stalks can be cut easily and very rapidly. The plants are allowed to fall over in such a way as to leave all the butts one way in the row and facing those of an adjoining row. This greatly simplifies the subsequent handling of the plants, which are allowed to lie on the ground until wilted to such an extent that they can be handled without much breaking of the leaves. It is customary to wait until the dew is nearly off the ground before beginning to cut the plants in the morning, and care should be taken not to cut more during the day than can be handled before night. Tobacco may be seriously damaged by lying on the ground overnight, especially in case of rain. Due care must be taken also not to allow the leaves to become sunburned or blistered during the hottest part of the day. For this reason some prefer to cut the tobacco on a cloudy day.

The old method of stringing the plants on poles in the barn with twine has now been almost entirely abandoned, so that nearly all tobacco is cured on laths. By the old way the loose plants were hauled into the shed to be strung on the poles, while by the new method they are placed on the lath in the field. These laths are about twice the thickness of ordinary plastering laths, 4 feet in length, and generally carry 6 plants. The plants are attached to the lath in one of two ways. In the first case, a sharp-pointed spearhead is slipped over the end of the lath, by means of which the tobacco stalks are pierced through from 4 to 6 inches from the end and slipped on to the lath, the latter being held in a hurdle for this purpose, as shown in figure 3. In the second case, hooks are attached to either side of the lath, on which the plants are hung. On one side the first hook is placed 6 inches from the end, and on the other side a second one is fastened on 13 inches from the end, and so on, the lath thus carrying 6 hooks alternately arranged on either side about 7 inches apart. The plants can be hooked on in this way very rapidly and without being damaged, with the additional advantage that they are very accurately spaced on the laths.

Formerly it was the general practice to hang the laths bearing the plants on scaffolds in the field for several days before placing them in the barn for the final curing, but the more common way now is to haul the tobacco directly to the curing shed. The most convenient wagon rack for this purpose, which is very simple in construction, i shown in figure 4. If the plants are speared on to the lath, this is carried to the wagon as soon as filled, but if the hooked lath is used the plants are carried to the wagon and hooked on to this after it has been placed in position on the rack. The wagon rack for hauling to the barn referred to above is from 28 to 32 feet in length and will

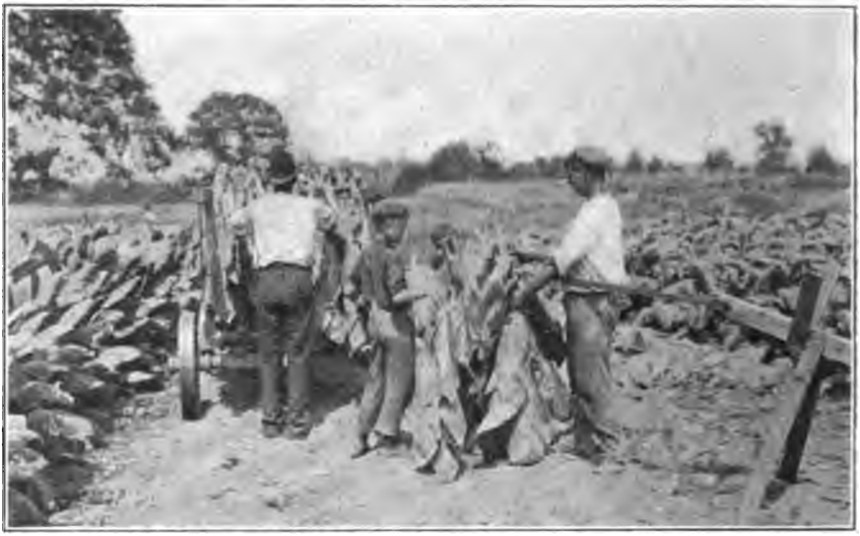

FIG. 3.—Tobacco field, showing the method employed in spearing plants on a lath, with the hurdle used for supporting the latter during the operation.

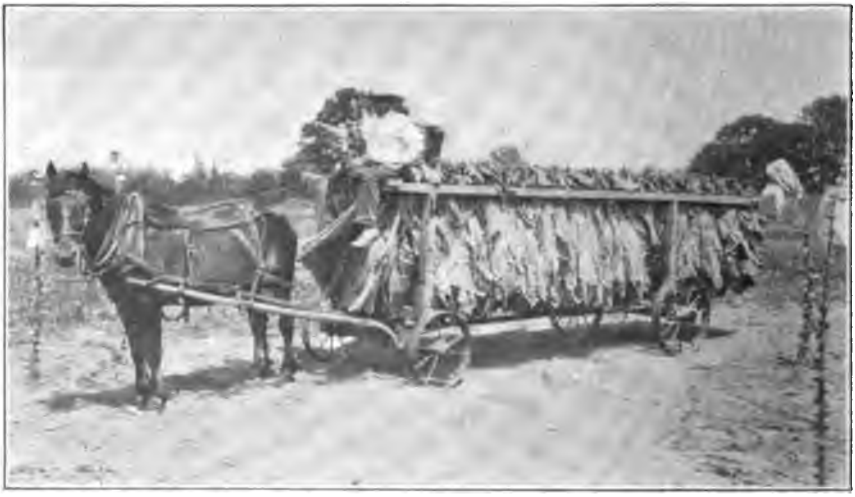

FIG. 4.—The best form of wagon rack for hauling plants to the curing barn.

rry from 80 to 120 laths of tobacco. As soon as loaded the wagon
iven directly into the barn and the laths are hung on the tier
which are about 4 feet apart.

The matter of properly spacing the laths on the poles is one of the greatest importance. This depends largely on the size of the plants, but for an average crop the laths may be hung 6 inches apart on the top tiers and this space increased downward so that on the bottom tiers they lie 8 inches apart. The laths are accurately spaced on the poles by means of a small block of the proper length, which is carried in the hand. Tobacco hung close together cures better in a dry season, whereas damage from pole-sweat is correspondingly increased in a wet season, but as there is no means of knowing in advance whether dry or wet weather will be encountered the best that can be done is to follow a middle course. The upper tiers of the barn are filled first, the laths being passed up from the wagon by means of a fork with a long handle made for the purpose.

For several days before filling the barn with tobacco the doors and ventilators should be kept open to thoroughly air out the building, and as soon as the barn is full all loose leaves and trash should be removed from the floor. It is also a good practice to spread a coat of lime over the floor, the object being to prevent any undue fungous growth which might favor the development of disease in the curing.

CURING CIGAR TOBACCO.

The changes in the composition and properties of the leaf which take place in the curing process, as well as the most favorable conditions for accomplishing these changes, have been fully discussed in the first part of this bulletin. The great difficulty at the present time lies in the fact that we have such limited means of controlling the conditions of temperature and humidity in the barn that we are largely dependent on outside weather conditions for effecting the cure. Nevertheless, it is important to make the best possible use of such means as are available for bringing about the highest development of the important qualities in the leaf.

At the present time no artificial heat is used in curing cigar tobaccos save in case of danger from pole-sweat, when charcoal fires are sometimes resorted to. The only means of regulating the humidity in the barn, therefore, lies in the control of the ventilation, and the temperature depends solely on that of the outside air. There can be no doubt that eventually some practicable means of controlling the temperature and humidity by the use of artificial heat will be devised, but meantime more or less damage must necessarily result every year because of unfavorable weather during the curing season.

The fundamental principle to be kept in mind during the first stage of the curing is to avoid too rapid drying out of the leaf. It is certain that many growers, in their anxiety to avoid damage from pole-sweat, caused by excessive moisture, injure their tobacco verseriously by going to the other extreme of drying out the leaf so rapidly as not to allow sufficient time for those changes to take place which are essential to good curing. As was explained in the first part of this bulletin, the essential changes taking place in the curing are dependent on the life activities of the leaf, and are therefore stopped as soon as this is killed by loss of water. Consequently, if the outside air is very dry the barn should be kept closed during the day and opened up at night. The object is to keep the moisture of the air in the barn quite high until the important changes in composition have taken place, as shown by the change in the color of the leaf from green to yellow. Warm temperatures also greatly favor these changes. Of course, if the outside air is quite humid the barn should be kept open during the day, and if it is moderately dry the ventilators should be opened only at the bottom.

As soon as the yellow color develops, the humidity in the barn should be reduced, for the development of the brown color which soon follows indicates that the leaf is beginning to die, and this is the critical stage in the cure. If the humidity remains very high at this stage for any considerable period, pole-sweat will surely develop. This is to be especially feared if a season of warm, foggy weather sets in, and may soon render the entire contents of the barn practically worthless. The only remedy lies in the use of artificial heat to keep down the humidity. Ventilation alone will be of little avail. The possible methods of supplying artificial heat have been discussed in the first part of this bulletin (see p. 20).

Entirely aside from the danger of pole-sweat, however, there are other important reasons why the humidity in the barn should be reduced as soon as the brown color begins to develop. The leaf dies at this stage and the true curing changes are stopped. All further changes in composition and properties are such as can be better controlled in the sweat room, where the ventilation, temperature, and humidity can be easily regulated, than in the curing shed. At the present time the demand is for bright colors in wrapper leaf, and the longer the second stage of the cure is protracted by a relatively high humidity the darker will the leaf be. Again, each time the tobacco comes into high case, after the cure is finished, the color will be further deepened. The rational method of procedure, therefore, is to maintain a high humidity during the first stage of the cure and then, as soon as the color has developed, to dry out the leaf comparatively rapidly. After the cure is finished, the tobacco should be prevented from coming into high case or order until it is to be taken down, so far as this is possible.

The time required for completing the cure varies from six or eight to twelve weeks, depending on the character of the season. As has been already stated, quick curing may be depended on to give the best results, provided the first stage is not unduly hastened. The cure is finished when the midrib of the leaf has dried out so that it will snap when bent between the fingers. When the tobacco is ready to be taken down, the stalks are still quite green, and would remain so for many weeks longer.

STRIPPING AND ASSORTING CIGAR TOBACCO.

As soon as possible after the tobacco is cured, the plants should be taken from the laths and the leaves stripped from the stalks. This can not be done, however, until after damp weather has prevailed long enough for the leaf to become pliable, so that it can be handled readily without breaking. Tobacco in this condition is said to be "in case" or "in order" and weather well adapted to bringing it into case is frequently spoken of as a "tobacco storm." Tobacco will not come into order, however, if the temperature be very low, even when wet weather prevails. If the stalks have been frozen it is well to leave the plants hanging until the dripping stops, so as to avoid staining the leaf.

As the plants are taken from the laths, they are piled in heaps on a floor of poles or boards, the tips all being turned inward and overlapping to prevent the leaves from drying out. The leaves should be stripped from the stalks as soon as possible after the plants have been taken down, so as to avoid the heaps becoming heated. All of the top leaves are first stripped off and placed in a pile designated as "fillers" ; then the next three or four are taken off and placed in a second pile called "seconds." Finally, the best leaves are classed as "wrappers," all damaged leaves being thrown out. These different grades are then tied into bundles, called "hands," using a leaf as a binder. The bundles should be made of leaves of uniform length and of the same quality, the whole weighing about one-half pound. Care must be taken to exclude from the best grade all leaves showing injury or discoloration. After the leaves have been tied into bundles these are arranged in bulks on an elevated platform. These bulks are built by laying the bundles in two rows with all the butts outward and the tips of the bundles in the two rows overlapping somewhat. The bulk is covered with oilcloth or other suitable material to prevent the leaves from drying out. They must be carefully watched to prevent their becoming heated, which is particularly liable to occur if the leaf is packed down too moist. If heating does occur, the piles must be torn down, and rebuilt after the bundles have been shaken out.

Before the leaf is ready for the manufacturer it must undergo a process of fermentation, commonly spoken of as "sweating." To carry out this process successfully requires a thoroughly equipped plant with adequate facilities for controlling ventilation, temperature, and humidity, so that as a rule the growers sell their leaf in the bundle to the dealers who make a business of carrying on the fermentation on a large scale. The tobacco must also be very carefully assorted into grades, but the dealer generally prefers to do this himself in order to secure greater uniformity; and the grower, unless thoroughly experienced in the business, does well not to attempt the work of grading. This work of grading and fermenting cigar-leaf tobacco has become a highly specialized industry, quite distinct from the curing process, properly speaking, and so does not require further consideration here.

SHADE-GROWN CIGAR-WRAPPER LEAF.

In recent years the growing of Cuban and Sumatran types of cigar-wrapper leaf under artificial shade has become a very important industry in portions of southern Georgia and western Florida and in the Connecticut Valley. The details of harvesting and curing this leaf differ in some important points from those employed for the ordinary types grown in the open air, and therefore require some further consideration. The barns, however, are of the same construction as those used in curing the tobacco grown in the open air, except that, since the leaves are picked from the stalk in harvesting, the tier poles are only 2½ feet apart vertically. The ordinary type of barn can therefore be very readily converted into one adapted to the shade-grown leaf by simply placing additional tiers of poles midway between the tiers already in position. A barn will hold about the same quantity of tobacco whether harvested on the stalk or by picking the leaves.

As has just been stated, all shade-grown leaf is picked from the stalk in harvesting, and this is done to insure the maximum yield of high-grade wrappers. Tobacco grown under shade does not show the ordinary signs of ripening so clearly as does that grown in the open air, and, moreover, to get the best results it is necessary to harvest the leaves before they would ordinarily be considered fully ripe. When ready for harvesting the lower three or four leaves are picked by hand and packed in baskets lined with burlap. The baskets, as soon as filled, are hauled to the curing shed, those exposed to the sun being covered with burlap to avoid injury to the leaves. A convenient rack for hauling the baskets to the barn is shown in figure 5. The field is gone over three or four times before all the leaves are harvested, the object being to pick all of them when at just the right stage of maturity.

In southern districts the leaves are strung on cords attached at each end to laths. These laths are of the same length but smaller than those used for curing tobacco on the stalk. A notch is made with a saw in each end of the lath and one end of the cord is drawn into one of these notches, wrapped around the end of the lath, and again drawn into the notch. The leaves, 30 or 40 in number, are then strung on the cord by means of a large steel needle and the free end of the cord is attached to the second end of the lath in the same manner as in the first case, care being taken to draw the cord sufficiently tight to prevent too much sagging. The leaves are strung on the cord in pairs, as it were, so that the front surfaces of each pair are face to face and the backs face the backs of adjoining pairs. This is done to prevent the leaves from sticking together as they curl up from loss of water.

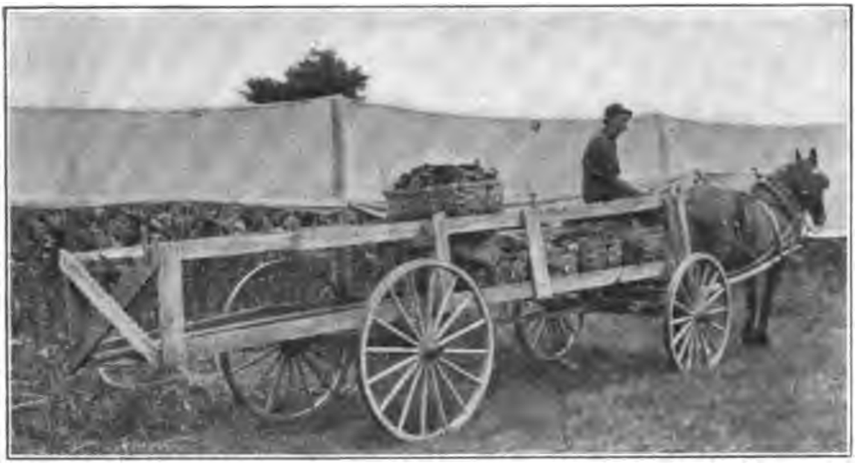

FIG. 5.—A very convenient wagon rack for hauling baskets of picked leaves to the curing barn.

In the Connecticut Valley some growers string their tobacco on cords in the manner just described, but a second method of hanging the leaves is coming into extensive use. Small, slender wire nails are driven through each side of the lath at an upward angle and at intervals of 2 inches, beginning 4 inches from the ends. This provides 40 spikelets in all, 20 on each side, and on each of these one leaf is hung. The leaves are all hung so as to face outward. In this case the leaves hang with their flat surfaces parallel to the long axis of the lath, while those strung on cords hang with their surfaces at right angles to this axis. Each of these methods of stringing the leaves possesses points of advantage, and it is difficult to determine just which is the better one. The work of stringing the leaf is usually done by girls or boys, some of whom develop remarkable dexterity. The laths carrying the leaves are hung on the tier poles at intervals of 4 to 6 inches, depending on the size of leaf. The method of arranging the laths on the poles in the barn is shown in figure 6.

MANAGEMENT OF THE CURING BARN.

The changes in composition of the leaf are doubtless of the same character as those which take place in curing tobacco on the stalk, but less complete than in the latter case. The two important differences in the two cases are that the picked leaves cure much more rapidly than those left on the stalk, and the conditions in the barn as to humidity and temperature are more easily controlled. Both of these facts are due to the circumstance that the stalks, which contain so much water and give up this water so slowly, are not placed in the barn when the leaves are harvested by picking.

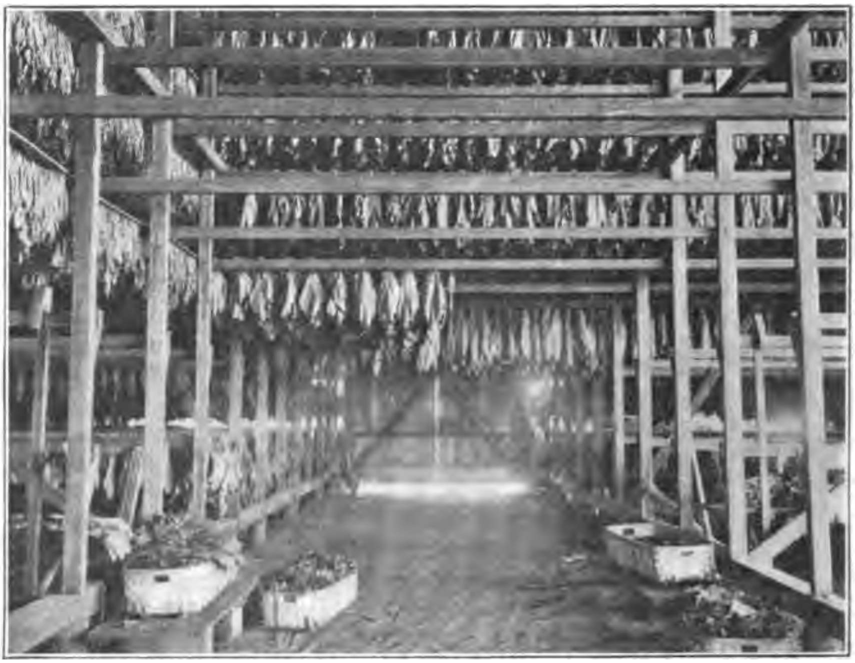

FIG. 6.—The interior of a cigar-tobacco barn, showing the arrangement of tier poles and the method of hanging picked leaves.

During the first stages of the curing due care must be taken to prevent the tobacco from drying out too rapidly. If the weather be very dry, the ventilators should be kept open for only a few hours in the morning. The picked leaves are whipped about by the wind more readily than those cured on the stalk, and hence the ventilators must be closely watched in windy weather to prevent injury to the tobacco from this source. As soon as the brown color develops, the leaf may be allowed to dry out rather rapidly. The leaf proper cures down in a short while, but a much longer time is required for completely drying out the stems. The picked leaves are subject to pole-sweat at the critical stage, the same as when cured on the stalk, but of course the danger period is much shorter in the former case. Under favorable conditions the curing will be completed in from four to six weeks.

After the tobacco is completely cured it is allowed to hang in the shed until the weather becomes sufficiently moist to soften the leaf so that it can be handled without breaking, when it is taken down and tied into bundles. If the leaves are strung on cord, this is cut from the lath, the leaves slipped to its center, and tied with the free ends. In this case the entire contents of the barn may be taken down before the tobacco is removed from the laths, these being piled in bulks on a temporary board floor. If the leaves are hung on the nail laths they must be stripped off from these as fast as they are taken down and tied into bundles in the same way as when cured on the stalk.

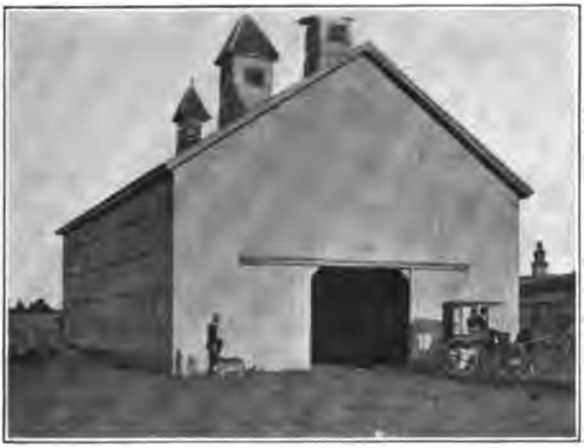

FIG. 7.—Type of tobacco barn used in the Burley district of Kentucky.

BURLEY TOBACCO.

Burley tobacco requires a fertile limestone soil for its highest development. The bulk of the crop is grown in the district embraced in the States of Kentucky and Ohio which borders on the Ohio River. Burley tobacco is also grown in considerable quantities in parts of Tennessee and West Virginia and in a small way in several adjoining States. Like cigar tobaccos, it is cured without the use of artificial heat except when there is danger of injury from house-burn, or pole-sweat. There are many types of barns in use for curing, ranging from the small crude log structure to the most approved modern frame building with ample facilities for controlling the ventilation. These modern barns are essentially the same as those used in the cigar-tobacco districts, which have already been discussed, and so need not be further described here. An approved type of barn is shown in figure 7.

HARVESTING BURLEY TOBACCO.

When fully ripe the plants are harvested by first splitting the stalk with a knife down about two-thirds of its length, then cutting it off near the ground and placing it astride a stick. The sticks are 4 feet 4 inches long and carry five or six plants, depending on their size. These are loaded on a rack similar to that shown in figure 4, hauled to the barn, and hung on the tier poles at intervals of about 12 inches. Some growers prefer to hang the tobacco on scaffolds in the field for two or three days, so as to allow it to become thoroughly wilted before housing it. In this case it can be safely hung considerably closer together in the barn than when carried directly from the field to the barn.

CURING BURLEY TOBACCO.

The method of curing is the same as for cigar tobacco, and the changes which take place are of the same kind. When cured, however, the color is yellow to red instead of the characteristic brown of cigar leaf. If the weather is dry, the barn should be kept tightly closed during the day and open at night, while in wet weather thorough ventilation is required. If the weather is very damp during the curing period, the leaf cures down too dark. Some growers use small charcoal fires to dry out the barn when pole-sweat sets in. From five to eight weeks are usually required for completing the curing process.

ASSORTING AND PACKING BURLEY TOBACCO.

When taken down from the barn, the leaves are stripped from the stalk and assorted. The usual grades are (1) sand leaves, (2) trash, (3) lugs, (4) bright leaf, (5) red leaf, (6) tips. The three first-named grades are used principally for smoking tobaccos, the bright leaf for plug wrappers, and the red leaf and tips for plug fillers. These different grades are tied into bundles containing from 10 to 20 leaves and bulked down. The tobacco may then be packed at once into hogsheads or it may be allowed to remain in the bulk all through the winter, in which case it is hung up in the barn in the spring, where it undergoes a sort of sweat or fermentation. In either event it is packed under pressure into large hogsheads, which when filled hold from 1,000 to 1,500 pounds, and it is then ready for transportation to market.

SUN-CURED TOBACCO.

In a few counties of Virginia in the vicinity of Richmond a type of tobacco is produced which is much esteemed as a plug filler. This tobacco is cured by a modification of the air-curing process, which seems to develop its characteristic properties. After harvesting it is hung on a scaffold in the field, exposed to the sun until nearly cured, and then carried to the barn, where it hangs until ready for stripping. If the harvesting is followed by a period of cloudy weather, the tobacco, of course, receives little or no sunshine, and the curing approaches more nearly that of the cigar and Burley types.

YELLOW TOBACCO.

The yellow type of tobacco can be successfully grown only on light sandy soils which are, in general, poorly adapted to the production of most other crops. The importance of the character of the soil is well illustrated by the fact that small areas on a farm may produce a bright yellow leaf of the finest quality, while other portions of the same farm will grow only a heavy dark type, suitable for export. The bulk of the bright yellow tobacco is grown in North Carolina and in portions of Virginia, South Carolina, and Tennessee.

Equally as important as the character of the soil is the manipulation of the curing process. No other type of tobacco requires so much skill, experience, and good judgment for successful curing. Lack of attention even for a few hours during the curing may practically ruin the entire contents of a barn. The distinctive feature of the method used for curing this class of tobacco is the use of flues for conducting artificial heat into the barn in such a way that the smoke and gases from the fire do not come in contact with the leaf. The heating is kept up continuously from start to finish, thereby greatly shortening the curing period. Thus, except under unusually adverse conditions, the curing proceeds at a given rate practically independent of outside weather conditions.

CONSTRUCTION OF THE BARN FOR CURING YELLOW TOBACCO.

The type of barn most widely used in curing yellow tobacco is comparatively simple in construction and is characterized by its small size. These barns are generally, but not always, built square and vary from 16 to 24 feet in width, inside measurement. It is necessary that the inside width of the barn be some multiple of 4 feet, since this is the distance between the tier poles which extend across the barn lengthwise and receive the sticks on which the tobacco is hung. The first set of tier poles is placed 9 feet above the ground and each succeeding set 2 feet 8 inches to 3 feet higher. The smaller sized barns are usually built 17 feet high to the eaves, and therefore contain four sets of tier poles, while the larger ones are frequently built 20 feet high and contain five sets of tier poles. Additional tiers may be placed in the roof.

The barns are generally built of logs, but many framed structures have been erected in some sections in recent years owing to the increasing scarcity of timber. When logs are used, the cracks are either chinked with mud or closed with lime mortar. A typical log barn is shown in figure 8. If framed barns are built, the cracks should be battened with thin strips of boards. Ventilation is usually secured by leaving openings around the bottom of the barn and by cutting small windows in the gable ends near the roof, which can be closed when desired. Many barns contain so many cracks and crevices, especially about the roof, that they require no special ventilators, but such barns are poorly adapted to curing yellow tobacco.

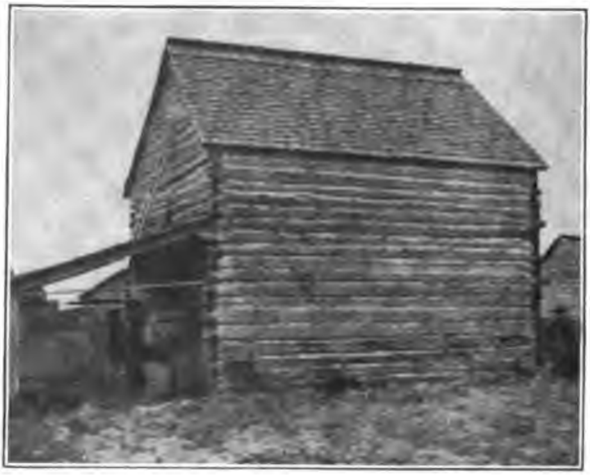

FIG. 8.—A typical log barn used in curing yellow tobacco, showing the ventilator in the gable and the outside portions of the heating system.

As explained in the first part of this bulletin, it is important to keep the barn tightly closed during the first stage of the curing, while in the second stage it is even more important to have ample ventilation. These requirements can only be met by building the barn as tight as practicable in the first instance and then providing a system of ventilators which can be opened and closed at will. Any reasonable outlay to secure these ends will be amply repaid, both in saving of fuel and in obtaining a finer quality of cured leaf.

The heating system consists of a series of sheet-iron flues leading from small furnaces placed at one end of the barn. The arrangement of the flues is comparatively simple, but is variously modified in different sections of the flue-curing belt. One of the best arrangements for the larger sized barns is that shown in figure 9. The furnaces (fig. 9, F, F) are built of stone or brick and are usually about 18 inches wide and 20 inches high, inside measurement. The tops are arched and the walls are made sufficiently thick to avoid all danger of igniting the walls of the barn. The furnaces are built from 4 to 5 feet long, and project on the outside about one-fourth of their length. The flues are made in sections similar to ordinary stovepiping and are from 10 to 15 inches in diameter. These flues are fitted into the ends of the furnaces at A, A, and extend thence across the barn to B, B, where they turn at right angles and, continuing to C, C, they once more turn at right angles and finally pass outward through the wall at D, D. The flues are slightly inclined upward throughout their length and pass out through the barn wall about 3 feet higher than the mouth of the furnace. A smokestack

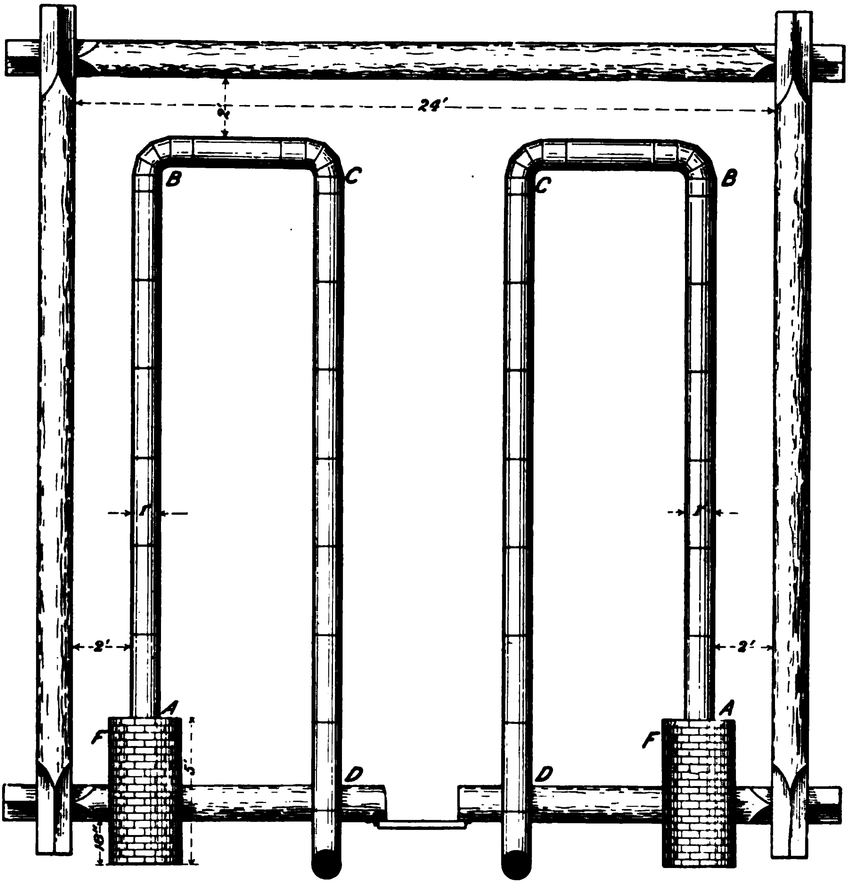

FIG. 9.—Sketch showing the arrangement of furnaces and flues in a barn adapted for curing yellow tobacco: F, F, brick furnaces; A, B, C, D, sheet-iron flues.

3 or 4 feet in height, the upper end of which is provided with a hood, is fitted to the outer end of the flue.

This arrangement of the flues is modified in a variety of ways. The two flues may be united (see fig. 9, C, C), whence a single arm returns to the side of the barn from which the furnaces enter, thus giving three lengths of pipe across the barn instead of four. In the smaller barns a single furnace placed in the center of one end is often made to supply the necessary heat. In this case a single flue leads across the barn and then branches at right angles, each arm returning along the side walls, thus simply reversing the last-described arrangement. Whatever arrangement is used, the flues should in no case be placed within 2 feet of the walls of the barn, and they must, of course, be surrounded with sheet tin or other suitable material at the point where they pass through the wall.

HARVESTING YELLOW TOBACCO.

There are two general methods of harvesting yellow tobacco, in one of which the entire plant is cut, while in the other the leaves are stripped off as fast as they ripen. As a rule, the latter method is generally used in the newer districts, while the practice of cutting the entire plant has many adherents in the older districts. The merits of these two methods of harvesting have already been discussed in Part I (p. 10). Whichever of the two methods is used, the leaf should be riper before housing than is the case with almost any other tobacco. The entire plant should have a yellowish green cast, while the leaf should show numerous flecks of a lighter tint in which the yellow is more pronounced. To obtain the best colors in curing requires that the tobacco be harvested at just the right stage, and here experience and good judgment are essential.

When the method of picking the leaves from the stalk is followed, three or four of the bottom leaves are stripped off at the first harvest. This process is repeated three or four times till all of the leaves have been harvested. The leaves are placed in baskets and hauled directly to the barn or to a temporary brush arbor, which protects them from the sun, and are then hung on sticks. There are two ways of attaching the leaves to the sticks, which are generally cut 4 feet 4 inches in length. In the one case a stout cord is fastened to one end of the stick and drawn into a notch which has been previously sawed in the end of the stick. A few inches from this end the cord is passed once around a bunch of three or four leaves, which will thus hang to one side of the stick. The cord is then drawn to the opposite side of the stick and similarly passed around a second bunch of leaves, the whole process being repeated till the stick is full. Each stick will thus carry from 20 to 30 bunches, arranged alternately on either side. Another method consists in stringing the leaves on a series of wires, about 10 inches long, which are attached to the stick with small staples at intervals of about 8 inches, as shown in figure 10. These wired sticks carry about the same number of leaves as those on which cord is used. They possess a serious disadvantage in that the tobacco must first be stripped off before it can be bulked down.

When the entire plant is harvested the stalk is first split from the top down to near the bottom leaves and then cut off near the ground. The plants are then inverted and placed astride a stick, each stick receiving 6 to 8 plants. The tobacco is loaded on the wagon in "coops," or square heaps, with the tips of the plants toward the center, or a better way is to haul it to the barn on a rack, such as is shown in figure 4. The sticks are hung from 8 to 12 inches apart on the tier poles.

CURING YELLOW TOBACCO.

The flue-curing process is the only method of curing tobacco in use at the present time which affords the means of controlling the temperature and humidity in the barn. The nature of the changes in composition and properties of the leaf which takes place in the process of curing and the relation of temperature and humidity to these changes have been discussed in the first part of this bulletin. A large number of formulas for curing yellow tobacco have been used with more or less success, but the universal experience has been that any formula will require some modification for every curing made. The principal reason for this lies in the fact that all these formulas are based solely on temperature, which is only one factor. To the experienced grower the thermometer is a valuable aid, but the condition of the tobacco is watched as closely as is the thermometer.

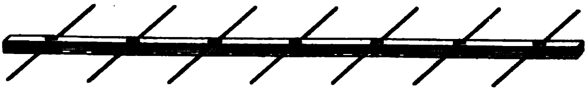

FIG. 10.—Stick with wires used in the yellow-tobacco districts for hanging picked leaves in the curing barn.

The barn should be completely filled in one day, and when this is done a thermometer is hung on the lower tier and near the center of the barn. Small fires are started in the furnaces and a very moderate temperature maintained until the leaf is thoroughly yellowed. During this period, from twenty-four to thirty-six hours, the barn should be kept tightly closed. The yellowing may be accomplished at any temperature between 80° and 120° F., and it is well to start with the lower temperature and gradually raise it up to 110° or 120° F. at the completion of the process.

The completion of the yellowing process ends the first stage of the curing, and then begins the critical period commonly spoken of as "fixing the color." The sole object at this stage is to remove the moisture as fast as it is given off by the leaf, and plenty of ventilation is essential to success. The tobacco should be closely watched, and if particles of water begin to show on the surface of the leaf more ventilation is required. Care should be taken that the temperature does not fall, and the best results are obtained when it is gradually increased throughout this phase of the curing until 130° to 135° F. is reached. If insufficient heat is supplied and, more important still, if there is not ample ventilation, the leaf will redden or "sponge." If the heat is increased too rapidly while the leaf is still full of sap, a greenish black discoloration will develop, which is known as "scalding" or "blistering." The nature and causes of these troubles have been discussed in Part I (p. 24). The remedy lies in a moderate and carefully regulated temperature, together with plenty of ventilation.

The temperature should be maintained at from 130° to 140° F. until the leaf is completely dried out, which will require about ten to eighteen hours after the completion of the yellowing process. All danger from sponging or scalding is now past, and it only remains to dry out the stems. The ventilators are now closed and the temperature raised up to 165° or 170° F. at the rate of about 5 degrees an hour. This latter temperature is maintained till all stems are completely dried out. Some raise the temperature as high as 190° and even 200° F., but this greatly increases the danger of burning up the barn and contents, an accident which is by no means of rare occurrence. When the tobacco is to be taken down the barn is left open during the preceding night so that the leaf may absorb sufficient moisture to bring it into condition for handling. If the leaf can be folded in the hand without breaking the stem it is in proper condition to be taken down without injury.

HANDLING YELLOW TOBACCO AFTER CURING.

When taken down the tobacco is carried to the packing house, where it is bulked down without removal from the sticks. The bulks are built up with all the butts pointing outward and the tips overlapping in the center. The heaps are usually made 4 or 5 feet high and may be of any convenient length. In order to avoid injury from mold the bulks should be torn down at the end of a week and, if desired, rebuilt. This treatment greatly improves the color of the leaf and especially assists in bleaching out the green remaining in the leaf after the curing. It frequently happens that the entire contents of a barn showing a decided greenish cast will come from the bulk with a beautiful clear lemon-yellow color, provided the green has not been set by drying out the leaf too rapidly in the first stage of the curing.

When the bleaching process has been completed the leaves are carefully assorted into from six to ten grades, based mainly on color and freedom from holes or spots. Yellow tobacco is classified on the market into (1) wrappers, consisting of the most perfect leaves; (2) cutters, leaves deficient in color and inferior to wrappers; (3) smokers, bottom or sand leaves and others bruised or torn and lighter in body than cutters; and (4) fillers, everything not included in wrappers, cutters, or smokers. Each of these four classes is subdivided into two or more grades. The finest grade of wrappers is bright lemon-yellow in color and composed of leaves free from imperfections and possessing sufficient toughness and elasticity. The next best grade is orange-yellow in color, and then comes the light reddish brown grade, known as " mahogany wrappers."

Market prices are greatly influenced by the care and skill used in grading yellow tobacco, and this work requires experience and the ability on the part of the assorter to accurately classify colors. Each grade is tied into small bunches, or " hands," and the leaf is then ready for market. If the market conditions are unfavorable the tobacco may be bulked down and kept in this way until placed on the market.

HEAVY EXPORT TOBACCOS.

The method in use for curing the heavy export type of leaf is a sort of combination of the air-curing and the flue-curing processes, although historically it is perhaps the oldest of all the methods of curing tobacco. The first stage in the curing is carried out without the use of artificial heat, and is therefore identical with the air-curing method, as applied to the cigar and Burley types. In the later stages small fires are kindled on the floor of the barn and the smoke is allowed to pass up through the tobacco, thereby imparting to it a characteristic odor, as well as materially augmenting its keeping qualities.

The old type of barn used for curing export tobacco is very similar to that in general use for curing yellow tobacco. It was built of logs, the cracks being daubed with mud. These barns were small in size, but were generally built high enough to contain five sets of tier poles. In recent years the log barns have been partly replaced by more modern frame buildings of much larger size. These are provided with large doors opening into passageways which lead through the building, thus allowing a loaded wagon to be drawn directly beneath the tier poles. These tier poles are arranged at intervals of about 3 feet 10 inches horizontally and 3 feet vertically, the first set of poles being 8 or 9 feet above the ground.

HARVESTING EXPORT TOBACCO.

The class of heavy export tobacco as a rule matures considerably later than the bright tobacco, owing chiefly to the character of the soil on which it is grown. By allowing it to stand in the field for several weeks after topping there is a decided gain in size and weight of the leaf. When ready for harvesting the leaves droop, they are thick and heavy, mottled with yellow flecks, and break readily when folded between the fingers. As a rule, the plants do not all ripen at the same time, so that it is necessary to make two cuttings. It is not desirable to harvest the tobacco immediately after a heavy rain, for the reason that much of the gummy matter secreted by the leaf is dissolved by the water, resulting in a considerable loss of weight.

In harvesting, the stalk is first split down to within a few inches of the bottom leaves and then severed near the ground. As soon as sufficiently wilted to be handled without breaking the leaves, the stalks are placed astride a stick and are then ready for carting to the barn. The sticks upon which the plants are hung are usually 4 feet 4 inches in length, and each stick carries from six to ten plants, depending on their size. The sticks carrying the plants are piled in squares on the floor of the wagon for hauling to the barn, with the tips of the plants pointing to the center; or a better way is to suspend the sticks on a long rack, as shown in figure 4. They are hung on the tier poles at intervals of from 7 to 10 inches. Some growers prefer to hang the tobacco on scaffolds in the field for several days before housing, in which case the plants are placed closer together in the barn.

CURING EXPORT TOBACCO.

No heat is used for the first three or four days of the curing period, for if applied at this stage the leaf would dry out too rapidly. It is important to avoid this drying out of the leaf before the proper colors have been developed and other important changes effected. In this case the leaf would be starchy and lifeless to the touch, deficient in those substances which impart to it toughness and elasticity. After the third or fourth day slow fires are started on the floor of the barn and the temperature maintained at 90° to 95° F. for about twenty-four hours. This moderate heat greatly facilitates the yellowing of the leaf. As soon as this is accomplished the temperature may be slowly increased till 125° or 130° F. is reached and held at this point till the leaf tissue is pretty well dried out. The fires are then allowed to die out, so that the leaf may again become pliable by the flow of sap from the stalk and stem.

This process of alternate drying out and softening of the leaf is repeated during several weeks, until the stem and leaf are both completely cured. During the first stages of the firing, when the tobacco is still full of sap, too much heat must be guarded against, else portions of the leaf will be discolored by "scalding," as in the case of flue-curing yellow tobacco. If the tobacco remains hanging in the barn for any considerable length of time after the curing is completed, slow fires should be started during periods of wet weather to prevent injury to the leaf from molds and also to prevent too much darkening of the color. Frequently the tobacco is improved by bulking it down without removing it from the sticks, as already described for yellow tobacco.

HANDLING EXPORT TOBACCO.

When the tobacco after being thoroughly cured has become pliable by the absorption of moisture during a damp season the plants are removed from the sticks and piled in heaps so arranged that all the butts face outward. Beginning at the bottom of the plant the leaves are stripped off and tied into small bundles according to grade. The poorest grade, composed of badly damaged and torn leaves, is known as "lugs." Those leaves which are inferior in color or damaged, but better than lugs, are designated as "seconds," while the remaining sound leaves are classed as "good." These good leaves are further subdivided into several grades, based largely on evenness and depth of color. It is also important to assort the leaves according to size, so that the same bundles shall not contain both long and short leaves. The finest grades are usually put into bundles of only five or six leaves, while the bundles of poorer quality may contain eight or ten leaves.

The profits in growing shipping tobaccos depend in large measure on the skill and care used in assorting and handling the cured product. This class of leaf is sold by sample, and a few badly graded leaves drawn for this purpose will necessarily lower the valuation of the entire lot represented by this sample. Care must also be taken that the tobacco does not contain too much moisture when packed down, for in this case it will be damaged by mold as soon as warm weather sets in. Tobacco offered on the market in this condition will only be taken by those prepared to rehandle it. It is far better to "reorder" such tobacco by again hanging it in the barn until well dried out. It is then ready for taking down again as soon as favorable weather for handling develops. To preserve them in fit condition for packing, the bundles are then bulked down on an elevated platform and the bulks covered with blankets.

In a few weeks after being bulked down the tobacco is packed, or "prized," into large casks. There is much variation in the dimensions of casks used in different localities. The bundles are packed in the hogsheads in closed or cylindrical form instead of spreading out the tips of the leaves, as is done with some types of tobacco. A screw press is used in packing the casks under the proper pressure. These casks or hogsheads contain from 1,000 to 2,000 or more pounds of leaf, depending on the grades, the best grades being packed in smaller quantities. The casks are transported to the warehouse, where samples are drawn by sworn inspectors under state regulation, and the tobacco is sold at auction.

PERIQUE TOBACCO.

Although produced in relatively very small quantity, the type of tobacco known as " Perique " is specially interesting on account of the peculiar methods used in curing and preparing it for market. It is grown only in St. James Parish, La. On account of the soil and climate in this region, the tobacco grows very rapidly and is harvested in early summer. The plants are cut during the middle of the day and carried directly to the curing shed. They are suspended from ropes by means of short pieces of cane driven into the stalks at an angle near the basal end so as to form a hook.

No artificial heat is used in curing Perique tobacco. As soon as the leaf tissue assumes a brown color the leaves are stripped from the plant before the stems have cured. The leaves are stripped from the plant at intervals of a few days, only three or four being taken at a time. The leafy portion is stripped from the green stems and made into loose rolls which are packed into a small, square box having a capacity of 50 pounds. A pressure of several thousand pounds is brought upon the tobacco in the box and maintained for twenty-four hours. The rolls are then opened out and exposed to the air till the expressed sap has again been absorbed. The tobacco is again placed under pressure and the whole process repeated every twenty-four hours for a period of ten days. After this the manipulation is repeated at increasing intervals for several weeks till the leaf is fully cured and has assumed a black color.

Perique tobacco is generally spoken of as being "cured in its juices," and under this method of curing acquires a peculiarly fine aroma. The sap is repeatedly expressed from the leaf and thereby subjected to the oxidizing action of the air. This affords a completeness of fermentation which is not attained in any of the other methods of curing.

Perique tobacco is assorted into wrappers, fillers, and smokers. To prepare it for market the cured product is put up into 4-pound cylindrical rolls called " carottes." These are prepared by spreading a layer of the leaves, which have been opened out, upon a piece of cloth and covering them with a second cloth. The whole is then rolled into a hollow cylinder and the ends tucked in and tied. A coil of rope is next tightly wound around the roll by means of a windlass and the carotte is then ready for market.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 144.

B. T. GALLOWAY, *Chief of Bureau.*

APPLE BLOTCH,

A SERIOUS DISEASE OF SOUTHERN ORCHARDS.

BY

W. M. SCOTT, PATHOLOGIST,

AND

JAMES B. RORER, ASSISTANT PATHOLOGIST,
FRUIT DISEASE INVESTIGATIONS.

ISSUED MARCH 6, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of Chief of Bureau,
Washington, D. C., November 25, 1908.

Sir: I have the honor to transmit herewith a paper entitled "Apple Blotch, a Serious Disease of Southern Orchards," by Messrs. W. M. Scott, Pathologist, and James B. Rorer, Assistant Pathologist, of this Bureau, and recommend its publication as Bulletin No. 144 of the special series of the Bureau of Plant Industry.

This paper contains the first full account of the apple blotch, which has recently come into prominence as one of the most serious diseases of the southern portion of the apple belt. The life history of the fungus causing the disease has been worked out and the source of the annual infection determined.

It has been conclusively shown by the spraying experiments and demonstrations carried on by the Bureau for the past three years in the Ozarks that the disease can be successfully controlled at a nominal cost, and the results of this work are reported in this paper.

The writers wish to acknowledge their indebtedness to the members of the Benton County (Ark.) Horticultural Society for their hearty cooperation in connection with the field work reported upon in this paper.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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APPLE BLOTCH, A SERIOUS DISEASE OF SOUTHERN ORCHARDS.

INTRODUCTION.

Following the successful treatment of bitter-rot in Virginia in 1905 by the Department of Agriculture, demonstration work for this and other diseases was instituted in the Middle West in the spring of 1906. The demonstrations were primarily intended to show the best methods of controlling the apple scab and bitter-rot, both of which had been reported as very destructive throughout that region in previous years, but as the season progressed it was found that apple blotch was far more destructive than apple scab and bitter-rot combined. The writers, who were in charge of this demonstration work, naturally turned their attention to an investigation of the blotch disease.

The attention of the Department was first called to this disease in 1897, when specimens of it were received from Maryland and Texas. Mr. M. B. Waite photographed the affected fruits and determined the fungus to be a species of Phyllosticta. Since that time specimens of it have been received frequently from various parts of the eastern United States, but in no case was it reported as a serious pest. Upon inquiry, however, it was found that it must have been prevalent to an injurious extent in the Ozarks of Arkansas and Missouri for the past six or seven years. It has been commonly confused with apple scab and the damage done by it attributed to scab, which probably accounts for its serious nature having been overlooked until recently.

The disease is well distributed over the eastern half of the United States, having been recorded at the Department of Agriculture from Alabama, Arkansas, Georgia, Illinois, Kansas, Kentucky, Maryland, Michigan, Missouri, Nebraska, New Jersey, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, and West Virginia, but it reaches the height of destructiveness in the southern portion of the Ozark plateau. In northwestern Arkansas and portions of southern Missouri 75 per cent of the crop is commonly affected, and the disease is almost as bad in portions of southern Illinois. During September, 1906, the writers visited many of the orchards of Benton County, Ark., and found that fully 50 per cent of the fruit in these orchards was rendered unfit for barreling by this disease. From these observations it was estimated that the loss to the growers in this county alone amounted to $950,000. The disease was even worse in 1907, and although the crop was lighter the higher price of apples made the loss about the same as in the previous year. In 1908 the loss from the disease was immaterial, owing to the failure of the apple crop; however, the few apples that were produced were as badly affected with the disease as were those in the previous two years.

An examination made by one of the writers of orchards at various points in southern Kentucky and in Tennessee, Georgia, and Alabama showed that the disease was very destructive in those localities. Not only was the fruit of susceptible varieties rendered unfit for market, but the trees themselves were badly weakened by the cankers. On account of the disease the growing of several varieties well adapted to the locality has been practically discontinued. In certain sections of Alabama and Georgia the Ben Davis, Red Astrachan, Shockley, and Yates varieties, which formerly did well, have in recent years been almost a complete failure, owing apparently to attacks of this disease.

It appears, therefore, that apple blotch is the most destructive disease of the southern half of the apple belt. Occasionally bitter-rot, as in the year 1900, overshadows all other diseases in destructiveness, but taken year by year apple blotch is more serious. Fortunately the disease is amenable to treatment and can not gain a foothold in well-sprayed orchards. It is not sporadic in its nature and must accumulate on the twigs several years before a serious outbreak on the fruit can occur.

The disease as it appears on the fruit was first reported in 1902 by Clinton,[a] who attributed it to an undescribed species of Phyllosticta. In 1903 it was reported by Faurot [b] as occurring to a serious extent in southern Missouri, and in 1906 Crandall,[c] in connection with his work on liquid versus dust spraying, mentioned a disease which may have been the same thing. Scott and Quaintance,[d] in 1907, gave a detailed description of the disease on the fruit and the results of its successful control by spraying. Later in the same year Rolfs[e] published a description, with recommendations for its treatment.

The relation of twig cankers and leaf-spots to the fruit blotch was first reported by the writers[f] in 1907. Almost simultaneously

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[a] Illinois Agricultural Experiment Station, Bulletin 69, pp. 190–192, plate B, fig. 1, a, b, and c.

[b] Missouri State Fruit Experiment Station, Bulletin 6, pp. 7–8.

[c] Illinois Agricultural Experiment Station, Bulletin 106, pp. 217–218.

[d] U. S. Department of Agriculture, Farmers' Bulletin 283, pp. 14–18, fig. 2.

[e] Missouri State Fruit Experiment Station, Bulletin 16, p. 5.

[f] Proceedings of the Benton County (Arkansas) Horticultural Society, August 8, 1907.

Sheldon[a] reported observations which had led him to the same conclusions, and in addition he identified the fungus as *Phyllosticta solitaria* E. & E. Stevens[b] later in the same year recorded the canker form of the disease from several localities in North Carolina.

DESCRIPTION AND BEHAVIOR OF APPLE BLOTCH.

Apple blotch occurs on the fruit, branches, and leaves. Although the form on the fruit is by far the most important from an economic standpoint, the twig cankers play an important part in the life cycle of the fungus causing the disease.

FRUIT BLOTCHES.

The first evidence of the disease on the fruit is a very small, inconspicuous, light brown blotch which under a hand lens has the appearance of a stellate collection of brown fibers just beneath the epidermis. The blotch, spreading radially, increases in size, attaining a diameter of from one-eighth to three-eighths of an inch, sometimes one-half an inch, and becomes darker in color. The advancing margin is irregular and jagged and has a fringed appearance. On very young apples the points of infection occasionally show as small water-soaked areas, and in wet weather there may be a yellowish gummy exudation from the spots. Where the spots are numerous they often coalesce and form large blotches, which may cover half the apple or more. The fungus kills only the superficial cells (the epidermis and outer perenchyma), so that the continued growth of the uninvaded tissues beneath results in a cracking of the diseased areas. The cracks thus formed, though usually about half an inch long, may girdle the fruit and extend to the core. The cracks often intersect, forming a cross. The character of the spots varies somewhat on different varieties. There are all gradations, from those on the Missouri variety, which are quite large, much fringed, and smooth, to those on the Limbertwig, which are small, compact, and often umbonate. An occasional spot somewhat rectangular in shape may be decidedly sunken and quite black, with a definite margin. (See Pl. I, figs. 1 and 2, and Pl. II, fig. 2.)

Within a few days after the spots become visible, black pycnidia begin to develop on the diseased areas. Three or four to many occur on each spot, and they may be scattered promiscuously or grouped on a small blister cracked around the margin.

The general effect of the blotches on the fruit is to mar its appearance and render it unfit for packing. Moderately affected fruit, especially if not badly cracked, may be evaporated, but much of it can not be used for this purpose, owing to the difficulty of paring, and is a total loss except where it can be used for vinegar. A large percentage of the affected fruit drops prematurely, and unless utilized immediately becomes a total loss.

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[a] Science, n. s., 26, No. 658, pp. 183–185, August 9, 1907.

[b] Science, n. s., 26, No. 673, pp. 724–725, November 22, 1907.

TWIG CANKERS.

The fungus attacks fruit spurs, twigs, and rapidly growing shoots, producing characteristic cankers. On fruiting branches these cankers are small and rather inconspicuous, being about one-eighth of an inch wide and one-half an inch or more long. (Pl. I, fig. 4.) They first appear as small purple or blackish blotches. As they increase in size they become brown in the center, retaining a purple margin, but may finally become gray. The bark soon cracks around the cankers, especially along the lateral edges. On rapidly growing shoots, particularly water sprouts, the cankers have the same general appearance as on fruiting branches, but are much larger, often measuring an inch or more in length and sometimes girdling the stem. (Pl. I, fig. 3.) The longitudinal cracks appear not only along the edges but through the cankers, giving them eventually a rough and scurfy appearance. This is especially noticeable on those which are two or three years old. Cankers with spore-bearing pycnidia are first formed on the current year's growth during the summer and fall. The fungus lives over winter in the canker, and during the following spring extends its growth, enlarging the diseased area, and produces new pycnidia on the advancing margin. This growth may continue for several years, as fresh spores have been found on cankers evidently three or four years old. Frequently, however, the canker is cut off from the healthy tissue by cracks, dries up, and later the wound may heal over.

As a rule these cankers do not materially injure the tree, killing only a few small branches and water sprouts, but in the case of some varieties they are so numerous and extend so rapidly that they kill the large branches, and even the main limbs as well. A block of 200 Northwestern Greening trees at Lanagan, Mo., has been practically destroyed by this disease. When visited by the writers in the spring of 1907, the fruiting wood, water shoots, and even larger limbs were almost completely covered with cankers, and many of them were girdled, so that the trees presented a very ragged and sickly appearance. (Pl. II, fig. 1.) So far as the writers have observed, this is the only case in which trees have been killed by the disease, but frequently Missouri, Limbertwig, and Red Astrachan trees become so badly affected that much of the bearing wood is killed and the trees are materially weakened.

In 1906 Mr. H. W. Gipple, of Bentonville, Ark., called the attention of the writers to a disease which often kills a large percentage of the fruit buds in late summer, especially on Limbertwig, Missouri, and Ben Davis trees, and suggested that possibly the apple-blotch fungus was also responsible for this trouble. An investigation showed that both the apple-blotch fungus and the black-rot fungus (*Sphaeropsis malorum* Peck) were present in the diseased buds. Observations in the orchard and culture work in the laboratory showed that the apple-blotch fungus extended down from diseased leaf petioles into the twigs at the base of the buds, which were soon killed. It was found that Sphaeropsis soon invaded the diseased buds and perhaps assisted in killing them. This trouble begins to show about midsummer and becomes more pronounced as the season advances, sometimes injuring the fruit buds of a few varieties to such an extent that the crop the following year is almost a failure.

During 1907 a similar diseased condition of Winesap buds was found to be common in Arkansas and Missouri. As this variety is practically immune from the Phyllosticta disease, some doubt was thrown on the conclusion given above. Cultures from these diseased Winesap buds nearly always developed *Sphaeropsis malorum*, but failed to show the presence of Phyllosticta. It would seem, therefore, that at least in the case of the Winesap the black-rot fungus is capable of killing the buds without the aid of the apple-blotch fungus. However, a further investigation of the cause of this trouble is desirable.

LEAF SPOTS.

The spots on the leaves caused by the apple-blotch fungus are irregular, light brown, yellowish, or whitish, and quite small, measuring one-sixteenth inch or less in diameter. Each spot bears one to several small black pycnidia. These diseased areas are scattered promiscuously over the surface of the leaf, and frequently occur on the veins, midrib, and petiole. (Pl. I, fig. 5.) They are so minute that several dozen may occur on a leaf without attracting attention and perhaps without material injury, but in severe cases they become conspicuous by their numbers, several hundred frequently occurring on a single leaf. The badly affected leaves may drop prematurely or die and turn brown on the tree. The latter condition results from a girdling of the petiole by the fungus, and often in midsummer such susceptible varieties as the Missouri and Limbertwig show tufts of brown leaves involving half or more of the foliage. This results in a weakening, and in many cases the death, of the fruit buds for the following year's crop. However, as a leaf-spot disease it is of comparatively minor importance, the common leaf-spot being caused by *Sphaeropsis malorum* Peck, which produces much larger spots.

INFECTION PERIODS.

The twig cankers in which the apple-blotch fungus passes the winter are undoubtedly the chief source of infection. During the warm, moist weather of spring the fungus resumes activity and soon begins to produce spores, which ooze from the pycnidia in enormous quantities. These are readily carried by rain and other agents to the young fruits, twigs, and leaves, producing the first spring outbreak of the disease. According to observations made by the writers in the Ozarks during the past three years, infections begin to take place from four to five weeks after the petals have fallen, and the blotches on the fruit appear about three weeks later. In 1906 the apple petals were off by April 29, and the first spots on the fruit were observed on June 26, two months later, while in 1907 the petals were shed by March 31, a month earlier than the previous year, and the first blotches were seen on May 31. Although the most extensive outbreak occurs at this early period, infections continue to take place throughout the season, young spots being commonly found on the fruit up to picking time.

As is the case with other fungous diseases, outbreaks of apple blotch are more or less dependent upon weather conditions, although, unlike bitter-rot, it develops in cool as well as in warm weather. Rains or heavy dews are necessary for the germination of the spores and the spread of the fungus from the twigs to the fruit.

SUSCEPTIBILITY OF VARIETIES.

There is a great range in the susceptibility of different varieties to apple blotch, some being almost immune, while others under the same conditions become badly affected. Of the commercial varieties grown in the Ozarks, the Ben Davis, Missouri, and Limbertwig are most subject to the disease, the entire crop of these, especially in old unsprayed orchards, often being destroyed. The disease is equally bad on other varieties, such as the Northwestern Greening, Smith, and Maiden Blush. On the other hand, the Winesap, Jonathan, York Imperial, and some others, are almost immune.

The following is a list of varieties, given in the order of their susceptibility to the attacks of this disease. As this list is based solely upon observations made by the writers during 1906 and 1907, mostly in the Middle West, the arrangement is more or less tentative and will probably have to be changed somewhat when further studies are made:

Badly affected.—Northwestern Greening, Missouri, Ben Davis, Limbertwig, Red Astrachan, Smith, Maiden Blush, Lawver, Shockley, Clayton, Willow, Arkansas Black, and Gano.

Moderately affected.—Oldenburg, Benoni, Arkansas, Bradford, Ingram, Collins, Minkler, Rambo, and Golden Russet.

Slightly or not at all affected.—Grimes, Winesap, Jonathan, York Imperial, and Red Reese.

In addition to those mentioned in the above list the writers have observed the blotch in various sections on the following varieties: Sherman, Shannon, Arkansas Pippin, Bough, Baldwin, White Pearmain, Yellow Newtown, Smokehouse, and Northern Spy; also on the wild crab apple (*Pirus coronaria*) in Pennsylvania.

CAUSE OF THE DISEASE.

The apple-blotch disease is caused by a fungus belonging to the genus Phyllosticta. Clinton,[a] in 1902, after having submitted specimens of this fungus to both Ellis and Peck, concluded that it was a new species. However, in 1907 Sheldon[a] identified it as *Phyllosticta solitaria* E. & E., which was described in 1895[b] on leaves of the wild crab apple (*Pirus coronaria* L.). Sheldon did not examine the type specimens, but found that the spores of the apple-blotch fungus, on the wild crab as well as on the common apple, agreed with Ellis and Everhart's description.

Through the kindness of Dr. W. A. Murrill, assistant director of the New York Botanical Gardens, the writers were able to examine the type collection of *Phyllosticta solitaria*, and found that the spores were practically identical with those of the apple-blotch fungus (Pl. III, fig. 5) and that the spots on the leaves were of the same character as those described above on the leaves of the common apple.

LIFE HISTORY OF THE FUNGUS.

In 1906, when the writers first began to study the apple-blotch disease, very little was known of the fungus causing it. It was supposed that this fungus lived over winter in the fruits mummified by the disease and that these mummies furnished the source of infection for the new crop. An examination of a large number of such diseased fruits revealed so few spores that they could not be considered an important source of infection. The fungus evidently does live over winter in the mummied fruits and in the spring makes an abortive attempt to produce either perithecia or pycnidia, but as yet no ascospores and but few pycnospores have been obtained from this source. It was necessary, therefore, to look elsewhere for the source of spring infection.

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[a] Loc. cit.

[b] Ellis and Everhart, Proceedings of Academy of Natural Sciences of Philadelphia, 1895, p. 430.

In September, 1906, the writers found apple-twig cankers caused by a fungus which appeared to be the same as the apple-blotch fungus. The fungus from these twig cankers and that from the spots on the fruit grown in the same kind of medium under the same conditions were so similar in all respects that one could not be distinguished from the other. Moreover, spores from both agreed in color, shape, and size. It seemed evident, therefore, that the two diseases were caused by the same fungus. For like reasons it was suspected that the fungus causing the leaf spots and petiole cankers found associated with the twig cankers was also the same. (Pl. III, figs. 2, 3, and 4.) Definite proof of this was obtained by inoculation experiments made in the following year.

In the spring of 1907 at the time the first fruit infections were taking place spores were found oozing in great quantities from pycnidia on the twig cankers, strongly indicating that these cankers formed the principal source of infection for the first outbreak on the fruit.

Under favorable conditions the spores which are carried from the cankers to the young fruits, twigs, and leaves may germinate in fifteen hours, giving rise to one or two germ tubes, which soon penetrate the epidermis and form a much-branched mycelium. In the fruit the growth of the fungus is slow and restricted to a few layers of cells just beneath the skin. The mycelium spreads out from the point of infection in a somewhat stellate manner; the invaded tissues turn brown, producing the characteristic blotches as seen on the surface. In a short time the fungus begins to produce pycnidia, or small receptacles in which spores are borne. (See Pl. III, fig. 1.) These pycnidia develop beneath the epidermis and appear as small, black, raised points. When mature, they rupture the epidermis and emit the spores, which are abjointed from short sporophores, through a small opening called an ostiolum.

The spores are ovoid to elliptical ovoid, hyaline, unicellular, and measure 8 to 10 by 5.5 to 6.5 μ. They are enveloped in a gelatinous sheath, which is frequently prolonged at the apical end into a thread-like appendage. (See Pl. III, fig. 4.) These appendages are as a rule rather inconspicuous, usually difficult to discern on spores from dried material, but readily seen on those that have just reached maturity. They vary in length, but are generally about twice as long as the spore. They are apparently of the same nature as the appendages which occur on the conidia of *Guignardia vaccinii* Shear and *G. bidwellii* (Ell.) V. & R. as described by Shear.[a] The writers have observed similar appendages on the spores of *Phyllosticta minima* (B. & C.) E. & E., the fungus which causes the common maple leaf-spot.

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[a] U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 110. p. 15, 1907.

The pycnospores, which are produced in great abundance on young green fruits until nearly midsummer, germinate readily and under favorable conditions may reinfect the fruits, twigs, and leaves. As the fruit approaches maturity spore production ceases, although pycnidia-like bodies continue to be formed. It is possible that this is an attempt on the part of the fungus to produce an ascigerous stage, but an examination of a great quantity of diseased fruits both in the fall and in the following spring has failed to reveal any asci. The conceptacles are filled with irregular cell-like bodies rich in protoplasm, which may be abortive asci.

The growth of the fungus on the twigs is confined to the bark, where it kills the tissues and forms the cankers previously described. The formation of pycnidia begins soon after the cankers are visible and continues throughout the season as the cankers increase in size. These pycnidia produce spores in great abundance which are similar in all respects to those from the fruit and, like them, as shown by inoculation experiments, may infect fruit and leaves. The fungus is perennial in the cankers, enlarging the diseased areas from year to year.

CULTURAL CHARACTERS.

The fungus grows well on nearly all ordinary culture media, such as potato, apple, prune, and corn-meal agar, sterilized potato cylinders, beans, rice, corn meal, and apple twigs. On agar the vegetative growth is quite characteristic, producing an irregular dark gray mass of mycelium, which in its compact radiating appearance suggests the blotches on the fruit. (Pl. III, fig. 10.) The fungous growth is very dense but quite restricted. The mycelium is for the most part embedded in the agar and is greenish black, but the fungous mass has a grayish appearance on account of tufts of short, hyaline hyphæ, which are produced over the surface. On apple wood, rice, and corn meal the growth is more extensive and less compact than on agar.

The mycelium is made up of profusely branched, anastimosing, septate, thick-walled hyphæ about 2.5 μ in diameter. (See Pl. III, fig. 9.)

The fungus does not fruit freely on culture media, and so far the writers have been able to secure spore-bearing pycnidia only on sterilized apple wood and corn-meal agar. Pycnidia-like bodies are formed in great abundance on all media, but these are for the most part sterile. In apple-wood cultures the fungus generally fruits well, producing little groups of pycnidia rich in spores.

INOCULATION EXPERIMENTS.

To show that the fungus which causes the twig cankers is also the cause of the fruit blotch, a series of cross-inoculations was undertaken during the season of 1907. Owing to the press of other work the writers were unable to devote much time to these experiments, so that the results are not all that could be desired. The first inoculations were made on June 26, after the main natural infection period had passed and dry weather had set in.

As spores could not be obtained in sufficient quantities from the pure cultures then on hand, fertile pycnidia were carefully picked from thoroughly washed young cankers on the twigs and crushed in sterile water, thus liberating the spores. An examination of drops of this liquid showed that it was rich in spores of the canker fungus, and cultures made from it proved to be free from other fungi, but, as might be expected, were slightly contaminated with bacteria. This fluid, containing spores from young cankers, was applied with an atomizer to the fruit and foliage of a Ben Davis tree in a young orchard just beginning to bear, in which the disease had not yet gained a foothold. The fruit and foliage of another tree in the same orchard were sprayed with sterilized water containing spores obtained in a similar manner from pycnidia on the fruit. A third tree was sprayed with sterile water as a check. Although this experiment was made in a period of dry weather, the effects of the inoculation began to show in about a month. On July 24 numerous small blotches were found on the fruits which had been inoculated with the canker spores, as well as on those inoculated with the fruit-blotch spores. The characteristic spots on leaf blade and petiole were also found on both trees. A careful examination of the check tree, as well as of a number of others in the same orchard, revealed no such blotches or leaf spots. As the season advanced the blotches increased in size, and when the crop was picked on September 3, the following data were obtained:

Tree 1, inoculated with canker spores, gave 34 apples affected with a total of 114 blotches and 52 sound apples. Many of these latter were not inoculated because they were in the top of the tree and could not be reached with the atomizer. (See Pl. IV, figs. 1 and 2.)

Tree 2, inoculated with spores from the fruit blotches, gave 14 apples affected with a total of 97 blotches and 4 sound apples.

Tree 3, check, gave a total of 59 apples, only one of which was affected, and that with only one blotch. Another adjacent tree bore 61 apples, none of which were affected.

No cankers were found on the twigs of either inoculated tree, owing perhaps to the hardened condition of the bark brought about by the dry weather. However, the writers have not yet determined the conditions necessary for twig infection.

PREVENTIVE MEASURES.

The experiments and demonstrations conducted by the writers in 1906 show that the apple-blotch disease may be controlled by proper applications of Bordeaux mixture,[a] and these results were confirmed by similar work in 1907. In order to determine the number of applications required and the time at which they should be made the following experiments were carried out at Bentonville and Gravette, Ark.:

SPRAYING EXPERIMENTS AT BENTONVILLE, ARK.

In the orchard of Mrs. Sneed, at Bentonville, a block of eighteen-year-old Ben Davis trees which were badly affected with the disease the previous year and which are said to have never been sprayed before was divided into seven plots of six trees each and sprayed with Bordeaux mixture. Twelve trees were selected as checks and left untreated. The crop, including windfalls, from three trees in each plot and from six check trees was sorted with reference to blotch into diseased and sound fruit and the apples in each class counted. The treatment given and the results from each plot are presented in Table I.

TABLE I.—*Results of experiments for the control of apple blotch on Ben Davis trees, Bentonville, Ark., 1907.*

Plot numbers (3 trees of each plot).	Treatment with Bordeaux mixture (5-5-50 formula).				Fruit picked September 12 to 19.		
					Sound fruit.	Blotched fruit.	
					Number.	*Number.*	*Per cent.*
1	Apr. 27	May 22	June 15	July 5	4,056	208	4.9
2	Apr. 27	May 22	June 15		3,008	115	3.7
3	Apr. 27	May 22			4,292	606	12.5
4	Apr. 27		June 15	July 5	4,837	595	11.0
5		May 22	June 15	July 5	1,242	2,705	68.5
6			June 15	July 5	2,169	4,237	66.1
7				July 5	1,403	3,346	70.5
8, check (6 trees), no treatment.					1,103	10,235	90.3

In studying this table it should be remembered that the season was a month earlier than normal and that April 27, the date of the first application, corresponds to about May 27 of the previous year, both dates being respectively about a month after the petals had fallen. Moreover, it should be borne in mind that the weather turned dry about the middle of June, after which the rainfall was very light, so that but few infections took place during the remainder of the season. The last two applications, made on June 15 and July 5, were therefore of little value in the control of the disease; but during a season of ordinary rainfall infections take place throughout the season, making late spraying necessary for proper protection, as was demonstrated in the previous year's work.

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[a] U. S. Department of Agriculture, Farmers' Bulletin 283, pp. 17–18.

The most striking feature of this experiment, as shown in the table, is the effect of the first application, made thirty days after the petals fell. The disease was successfully controlled in all the plots which received this application, while more than half the crop of the plots on which it was omitted was affected. This will be clearly seen by comparing the results from Plots 2 and 5, both of which received three applications, the only difference being that the treatment of the latter was not begun until three weeks after that of the former. The crop of Plot 2 shows only 3.7 per cent of diseased fruit, while 68.5 per cent of that on Plot 5 was affected. Plots 3 and 6 may be similarly compared. The crop of the check trees was almost wholly destroyed by the disease, 90.3 per cent of the fruit being affected. This, when compared with Plots 1 and 2, in which less than 5 per cent of the crop was diseased, shows very strikingly the good results from timely applications of Bordeaux mixture. (Pl. V, figs. 1 and 2.)

This experiment was practically duplicated on a block of Limbertwigs in the same orchard, and the results are given in Table II, which follows.

TABLE II.—*Results of experiments for the control of apple blotch on Limbertwig trees, Bentonville, Ark., 1907.*

Plot numbers (2 trees of each plot.)	Treatment with Bordeaux mixture (5-5-50 formula).				Fruit picked October 5 to 10.		
					Sound fruit.	Blotched fruit.	
					Number.	*Number.*	*Per cent.*
1	Apr. 27	May 22	June 15	July 5	4,233	360	7.8
2	Apr. 27	May 22	June 15		7,170	386	5.1
3	Apr. 27	May 22			4,256	305	6.7
4	Apr. 27		June 15	July 5	6,824	646	8.6
5		May 22	June 15	July 5	8,115	6,515	67.7
6, check (4 trees), no treatment					3,158	17,688	84.9

The results on the Limbertwig trees, as shown in this table, were about the same as those obtained on the trees of the Ben Davis variety. Again the importance of the first application, April 27, is emphasized, the disease being controlled on all plots receiving this treatment. Plot 2, which received three applications, beginning on April 27, had only 5.1 per cent of the crop affected, while Plot 5, which received the same number of treatments, though beginning three weeks later, had 67.7 per cent of the crop affected. (Pl. VI, figs. 1 and 2.) This emphasizes the fact that in order to control the disease the treatment must be given before infections take place.

SPRAYING EXPERIMENTS AT GRAVETTE, ARK.

At Gravette, Ark., in the orchard of Mr. P. A. Rodgers, a combined experiment and demonstration was conducted. A block of 120 large Ben Davis trees was divided into 5 plots of from 12 to 40 trees each, Plots 3 and 4 constituting a demonstration of 60 trees. Plots 1 and 2, from which poor results were expected, were limited to a dozen trees each, and Plot 5, the check, consisted of 12 trees. Early in the season 3 average trees in each plot were selected and at picking time the crop, including all windfalls, was sorted and counted. The results are given in the following table.

Table III.—*Treatment and results in apple-blotch experiments, Rodgers orchard, Gravette, Ark., 1907.*

Plot numbers (3 trees of each plot).	Treatment with Bordeaux mixture (5-5-50 formula).						Fruit picked September 23 to 26.		
							Sound fruit.	Blotched fruit.	
							Number.	*Number.*	*Per ct.*
1	Apr. 4	....	....	June 5	July 5	Aug. 6	1,625	1,156	41.6
2	Apr. 4	Apr. 11	....	June 5	July 5	Aug. 6	4,769	2,348	32.9
3	Apr. 4	Apr. 11	May 2	June 5	July 5	Aug. 6	5,282	432	7.6
4	Apr. 4	....	May 2	June 5	July 5	Aug. 6	5,093	393	7.1
5, check (6 trees), no treatment	....	....	....	....	....	....	3,733	4,632	55.4

The results here confirm those obtained in the Bentonville orchard, and show that the application made on May 2, just before infection began, was more important in the control of apple blotch than all the others combined. Plot 4, which was sprayed according to the demonstration schedule, had only 7.1 per cent of the fruit affected with the disease, while 32.9 per cent of the fruit was diseased on Plot 2, which had the same treatment, except that the second application was made on April 11, a week after the petals fell, instead of on May 2, three weeks later.

In the spraying demonstrations conducted in 1907 the disease was as thoroughly controlled as in the previous year. At Gravette, in the orchard of Mr. J. T. Oswald, a block of 125 very large Ben Davis trees was sprayed April 7, May 3, June 6, July 6, and August 7, five applications in all. Twenty trees were left unsprayed as checks. The fruit from 9 average trees of the sprayed block was sorted and counted and 95.4 per cent found to be free from blotch, while a count of 3 check trees showed only 34 per cent of the fruit free from the disease. The results of the demonstration in the Rodgers orchard are shown in Table III, of which Plot 4 was given the demonstration treatment. The sprayed block yielded 92.9 per cent of sound fruit, and the checks only 44.6 per cent.

The spraying not only protects the fruit but the twigs as well, thus preventing the formation of cankers, the chief source of infection for the fruit. The value of one season's treatment in this connection was shown in experiments conducted in the orchard of Mr. H. W. Gipple, at Bentonville, Ark. Trees left unsprayed in 1906 and 1907 had 64.6 per cent of the 1907 crop affected with the disease, while trees sprayed in 1906, but left unsprayed in 1907, had only 27 per cent of diseased fruit. As shown by an examination of the trees, very few new cankers were formed on the trees sprayed in 1906, which undoubtedly accounts for the smaller amount of fruit infection in 1907. It would seem, therefore, that a few years' thorough spraying might exterminate the disease from an orchard.

STRENGTH OF BORDEAUX MIXTURE FOR APPLE BLOTCH.

In the experiments reported in this paper Bordeaux mixture composed of 5 pounds of bluestone and 5 pounds of lime to 50 gallons of water was used. In several other experiments conducted by the writers various strengths were used, and it was always found that the weaker mixtures were uniformly less effective against both apple blotch and bitter-rot. However, the mixture containing 4 pounds of bluestone controlled these diseases almost as well as the stronger one and has the advantage of being slightly less injurious to the fruit and foliage. It also developed from these experiments that an excess of lime in the Bordeaux mixture was slightly advantageous in respect to injury, the 4–4–50 mixture causing somewhat more injury than the 4–6–50 mixture. All things considered, the following formula is perhaps best for general use:

4 pounds of bluestone.
4 to 6 pounds of stone lime.
50 gallons of water.

To this should be added 2 pounds of arsenate of lead or 6 ounces of Paris green for the control of the codling moth and other insects. If a good lime which will entirely slake into a smooth paste is used, 4 pounds are sufficient, but if the lime is poor or partially air-slaked 5 or 6 pounds, or even more, may be required to get the least possible injury.

The usual directions for preparing Bordeaux mixture by dissolving the bluestone in one vessel, slaking the lime in another, and diluting each with half the required quantity of water before pouring them together through a strainer into the spray tank should be followed. For extensive operations an elevated platform large enough to accommodate the necessary barrels and tanks and high enough to allow the two diluted solutions to run by gravity into the spray tank or into a supply tank is almost indispensable. To facilitate the preparation of the mixture in large quantities stock solutions of bluestone and lime should be made.[a]

Most of the spraying was done with a gasoline power outfit, such as is shown in Plate IV, figure 3, although a hand outfit of the 50-gallon barrel type was used in a part of the work. The power machine was equipped with two 35-foot leads of discharge hose for the operators working from the ground and one shorter length (about 15 feet) for the use of the man in the tower spraying the tops of the trees. Each lead of hose was attached to a 10-foot bamboo spray rod fitted with a double Vermorel nozzle deflected so as to direct the spray inward and downward.

RECOMMENDATIONS FOR THE CONTROL OF APPLE BLOTCH.

As the principal infection period comes from four to six weeks after the petals have fallen, it is necessary for the control of this disease to have the fruit protected at this time, and as scattering infections continue to take place throughout the season a coating of the fungicide must be maintained until picking time. The number of applications necessary to afford this protection will depend upon the season, wet weather naturally requiring more than dry.

Ordinarily four applications of Bordeaux mixture will control the disease: The first, three to four weeks after the petals have fallen, which corresponds to the second application in the treatment of the codling moth; the second, about four weeks later, and the third and fourth at intervals of three weeks thereafter. The second and succeeding applications correspond with the treatment for bitter-rot, so that one course of treatment will control both diseases. While the disease can be readily controlled by the proper methods, very careful and thorough work is required.

A few days' delay in making the first application may result in an entire failure, and unless all the fruit is reached and well sprayed only partial success may be expected. The inner and higher portions of the trees, which in practice are often missed, should be thoroughly sprayed, as well as the outer and lower portions.

Neglect of pruning is conducive to the development of the disease. The fungus accumulates on the numerous twigs, branches, and water sprouts of unpruned trees, and these are an ever present source of infection for the fruit. Careful pruning will not only remove a large portion of the diseased twigs but will greatly facilitate thorough spraying.

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[a] For fuller information regarding the preparation of spraying mixtures, see U. S. Department of Agriculture, Farmers' Bulletins Nos. 243 and 283.

COMBINATION TREATMENT FOR APPLE BLOTCH AND OTHER DISEASES.[a]

The treatment for apple blotch conforms closely to that for apple bitter-rot and with one or two additional applications all the other important fruit and leaf troubles may be controlled. The following course of treatment is therefore recommended for orchards in southern sections, especially where apple blotch and bitter-rot occur.

First application.—When the cluster buds are well out, just before the blossoms open. This is the first treatment for apple scab and is of special importance for badly scabbing varieties, such as the Winesap, Arkansas, Arkansas Black, and Red June. It may be omitted from the Ben Davis, Gano, Jonathan, and York Imperial, which scab very little or not at all in most southern sections. This application also constitutes the treatment for the spring canker worm.

Second application.—Immediately after the petals fall. The work may be commenced when about two-thirds of the petals have dropped and should be finished within a week or ten days, that is, before the calyx lobes close. This constitutes the second application for scab and the first for the codling moth and is the most important treatment for both.

Third application.—Three to four weeks after the petals have fallen. This is the first and most important application for apple blotch and is the second treatment for the codling moth.

Fourth application.—Eight to nine weeks after the petals have fallen, or not later than June 25. This is the first treatment for bitter-rot, the second for blotch, and the third for the codling moth.

Fifth application.—Two to three weeks after the fourth application. This is the second treatment for bitter-rot, the third for blotch, and is also important for the codling moth.

Sixth application.—Three weeks after the fifth application. This is the last treatment for bitter-rot and blotch and is important to prevent late infections. It is also very important for the control of the second brood of the codling moth.

The course of treatment given above is intended for the control of all the important apple troubles, such as scab, bitter-rot, blotch, leaf-spot, codling moth, and canker worm, and does not apply to all varieties alike. For example, the Winesap, which scabs badly but is not susceptible to bitter-rot and blotch, should be given the first three applications, but need be sprayed thereafter only for the codling moth, using the arsenical alone. On the other hand, in the treatment of the Ben Davis, which does not scab in the South but is very susceptible to apple blotch and sometimes rots badly, the first application may be omitted except in restricted localities where the spring canker worm is a pest; and in the second application the formula may be reduced to 2 or 3 pounds of bluestone and 3 or 4 pounds of lime to 50 gallons of water in order to reduce the Bordeaux injury as much as possible.

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[a] Mr. A. L. Quaintance, of the Bureau of Entomology, is the authority for that portion of this schedule of treatments relating to the codling moth.

PLATES.

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DESCRIPTION OF PLATES.

PLATE I. (*Frontispiece.*) Apple blotch on fruits, twigs, and leaf. 1.—A mature Ben Davis apple affected with blotch, showing the general character of the blotches and the cracking of the fruit caused by the disease. 2.—Two Ben Davis apples about one-third grown, showing the disease as it appears on badly infected fruit about six weeks after infection. 3.—Portion of a water sprout from a Limbertwig tree, showing cankers in different stages of development. 4.—Twig of bearing wood from a Ben Davis tree, showing numerous cankers on and near the fruit spurs. 5.—A leaf from a Missouri tree, showing leaf spots and petiole cankers caused by the apple-blotch fungus.

PLATE II. Fig. 1.—View of a Northwestern Greening orchard in which the trees have been practically killed by apple-blotch cankers on the small shoots and larger limbs. Fig. 2.—Six Ben Davis apples about one-third grown badly affected with blotch.

PLATE III. Microscopic and cultural characters of the apple-blotch fungus. 1.—A vertical section of a single pycnidium from a spot on a Ben Davis apple, showing pycnospores in various stages of development × 185. 2, 3, 4, and 5.—Mature pycnospores of the apple-blotch fungus from various sources, showing appendages × 700. (2) From leaf spot on Missouri apple leaf; (3)from canker on Limbertwig water sprout; (4) from blotch on Ben Davis apple; (5) from type specimen of *Phyllosticta solitaria* E. & E., on leaf of *Pyrus coronaria*. 6, 7, and 8.—Germinating spores × 700. (6) In potato agar; (7) in apple agar, twenty-two hours after sowing; (8) same spore as figure 7, seventy-eight hours after sowing. 9.—Mycelium of apple-blotch fungus from corn-meal agar culture × 370. 10.—Two colonies of the apple-blotch fungus one month old growing in apple agar.

PLATE IV. Fig. 1.—A Ben Davis apple, showing blotches produced by inoculation with spores from twig cankers. Fig. 2.—A Gano apple, showing blotches resulting from natural infection. Fig. 3.—A power spraying outfit in operation.

PLATE V. Fig. 1.—Entire crop of apples from a Ben Davis tree sprayed three times, beginning at the right period for the control of the disease. The apples in the basket, 3.75 per cent of the crop, are the only ones affected with the disease. Fig. 2.—Entire crop from an unsprayed Ben Davis tree in the same orchard as the apples shown in figure 1. The apples in the pile, 94.36 per cent of the crop, are all affected with blotch.

PLATE VI. Fig. 1.—Entire crop of apples from a Limbertwig tree sprayed three times, beginning at the right period. The apples in the basket, 5.1 per cent of the crop, are the only ones affected with blotch. Fig. 2.—Entire crop from a Limbertwig tree in the same orchard as the apples shown in figure 1 sprayed three times, but the first application made too late. All the apples in the right hand pile, 67.7 per cent of the crop, are affected with blotch.

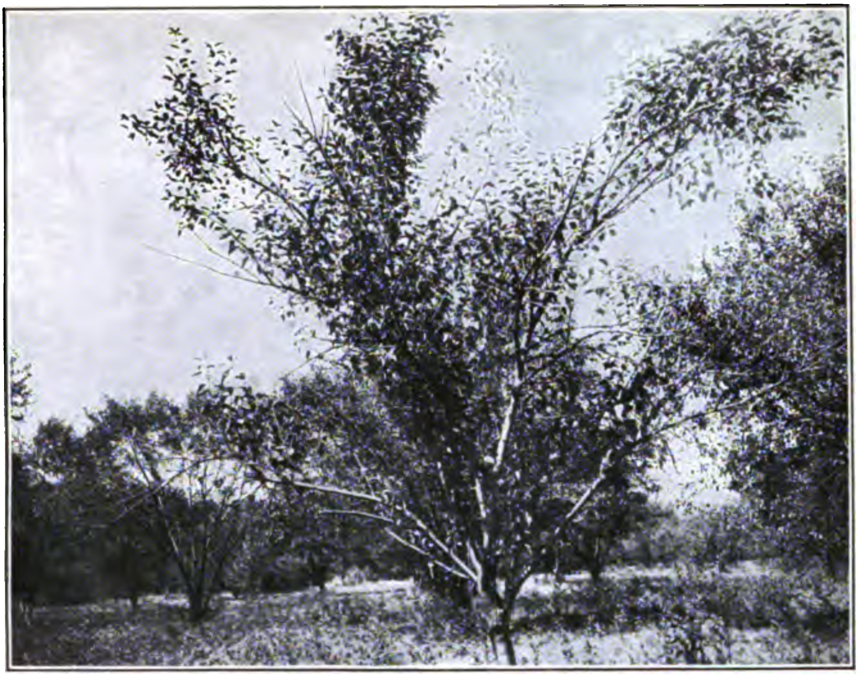

FIG. 1.—ORCHARD OF NORTHWESTERN GREENING APPLE TREES ALMOST DESTROYED BY APPLE BLOTCH.

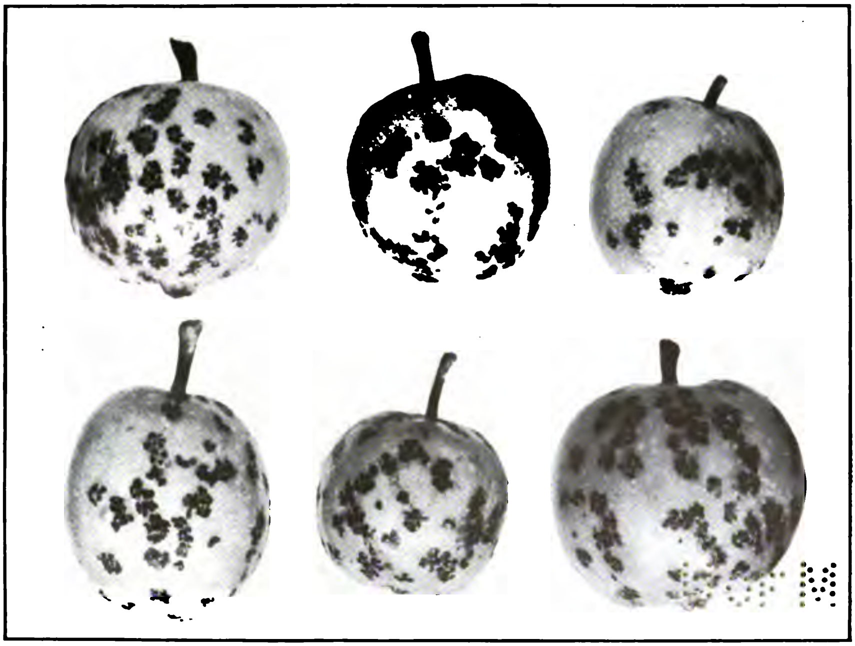

FIG. 2.—SIX BEN DAVIS APPLES, SHOWING THE CHARACTER OF THE DISEASE ON YOUNG FRUIT.

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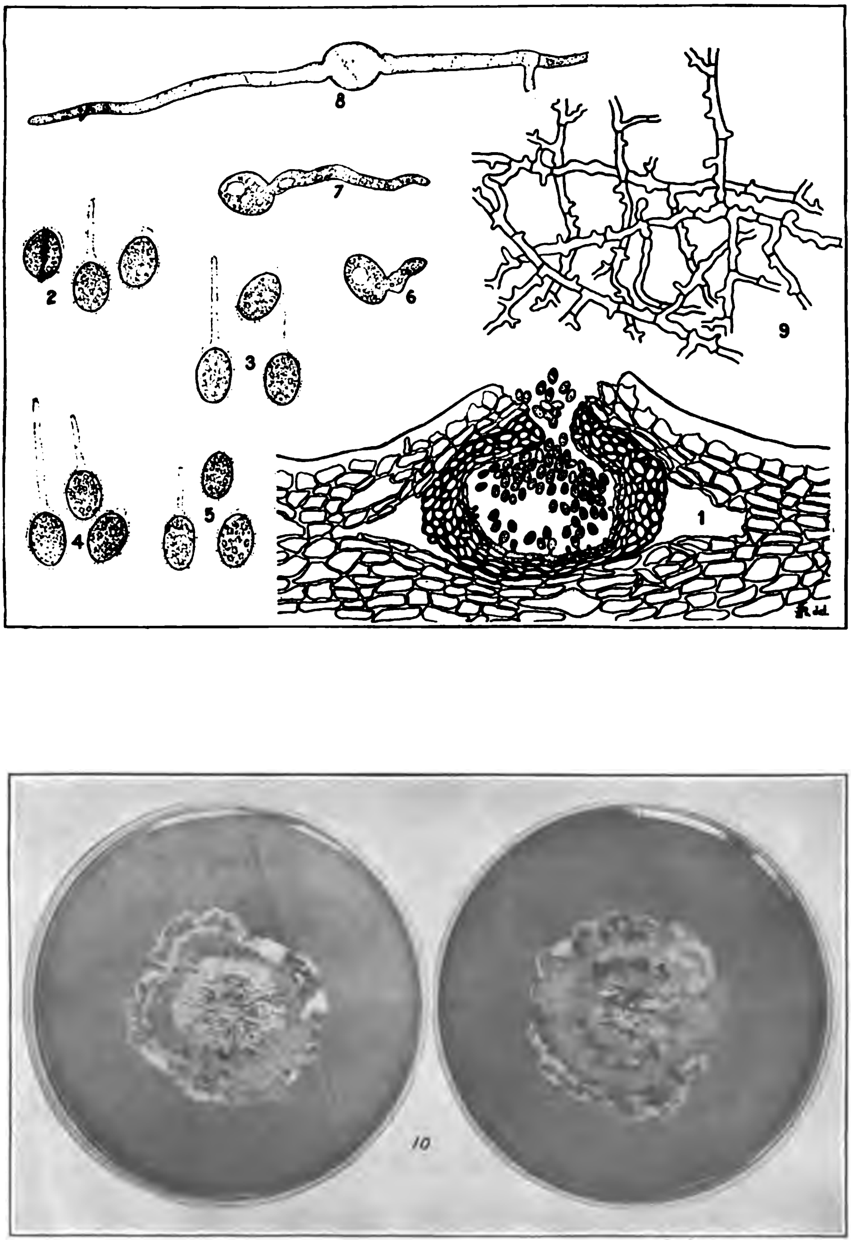

MICROSCOPIC AND CULTURAL CHARACTERS OF THE APPLE-BLOTCH FUNGUS.

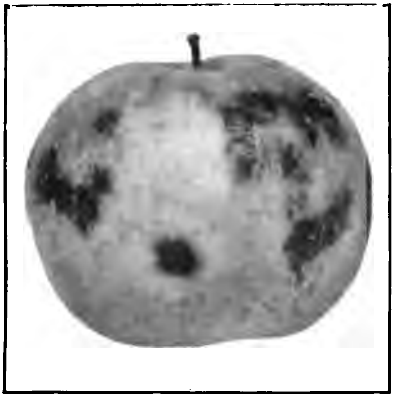

FIG. 1.—A BEN DAVIS APPLE, SHOWING BLOTCHES PRODUCED BY INOCULATION.

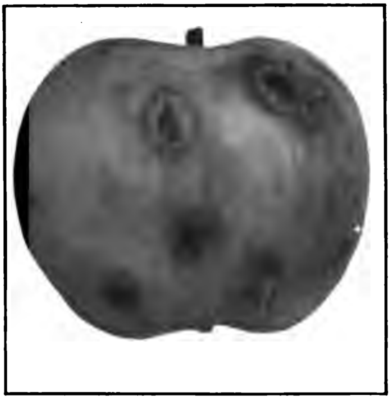

FIG. 2.—A GANO APPLE, SHOWING BLOTCHES RESULTING FROM NATURAL INFECTION.

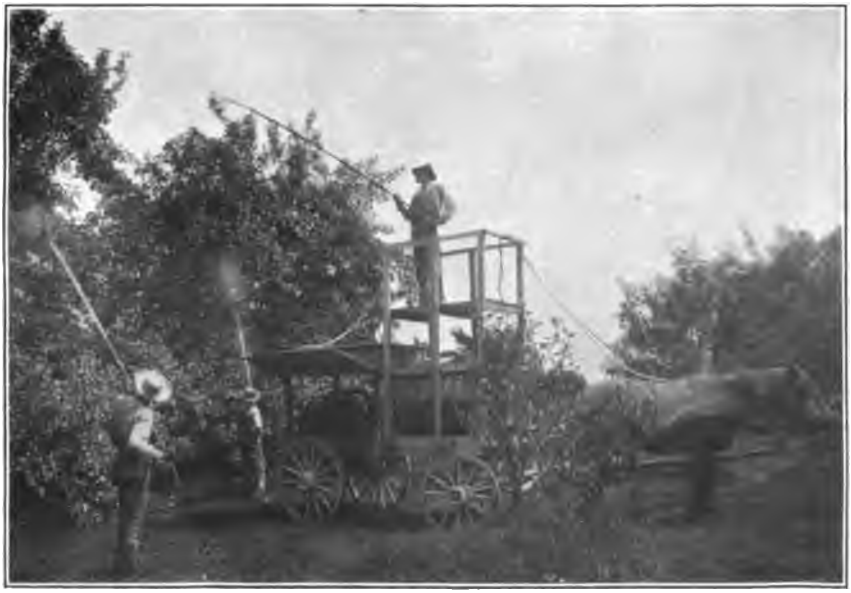

FIG. 3.—A POWER SPRAYING OUTFIT IN OPERATION.

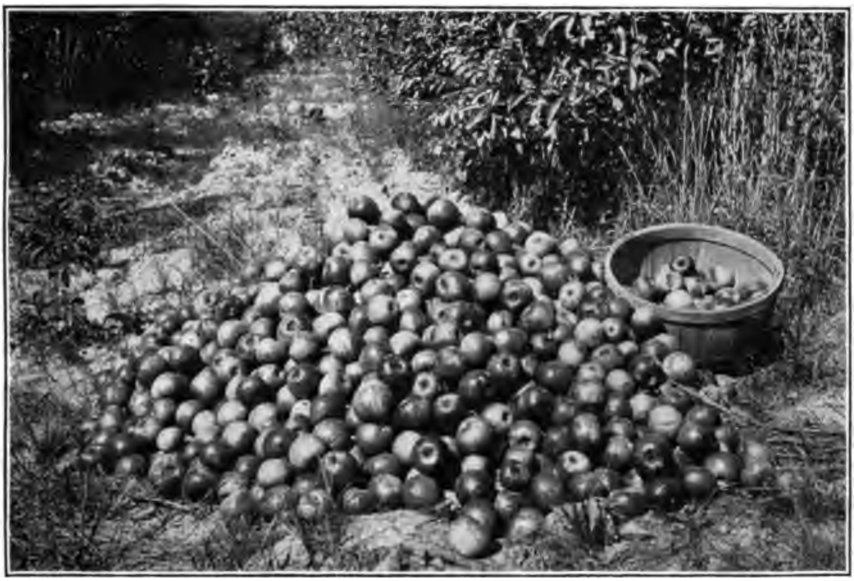

FIG. 1.—CROP OF BEN DAVIS APPLES FROM A PROPERLY SPRAYED TREE. SOUND FRUIT IN PILE.

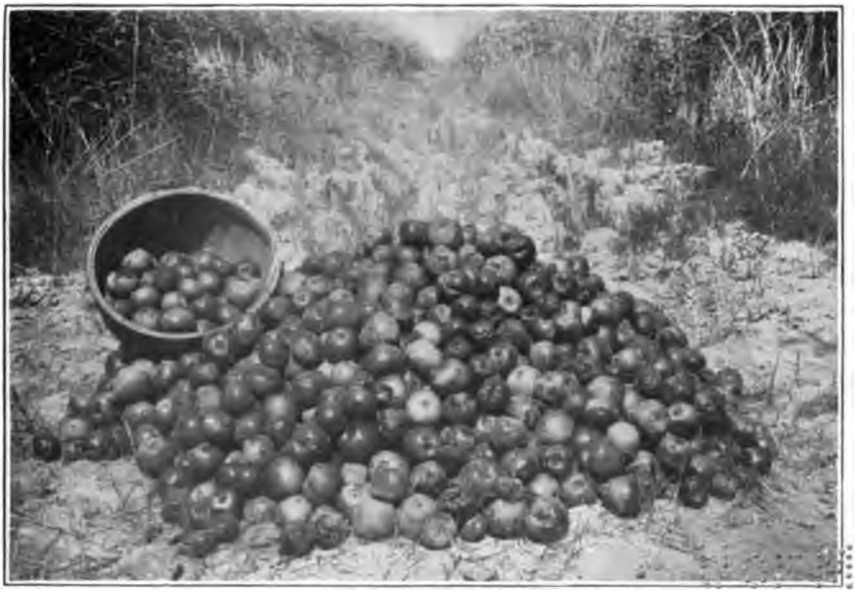

FIG. 2.—CROP OF BEN DAVIS APPLES FROM AN UNSPRAYED TREE. BLOTCHED FRUIT IN PILE.

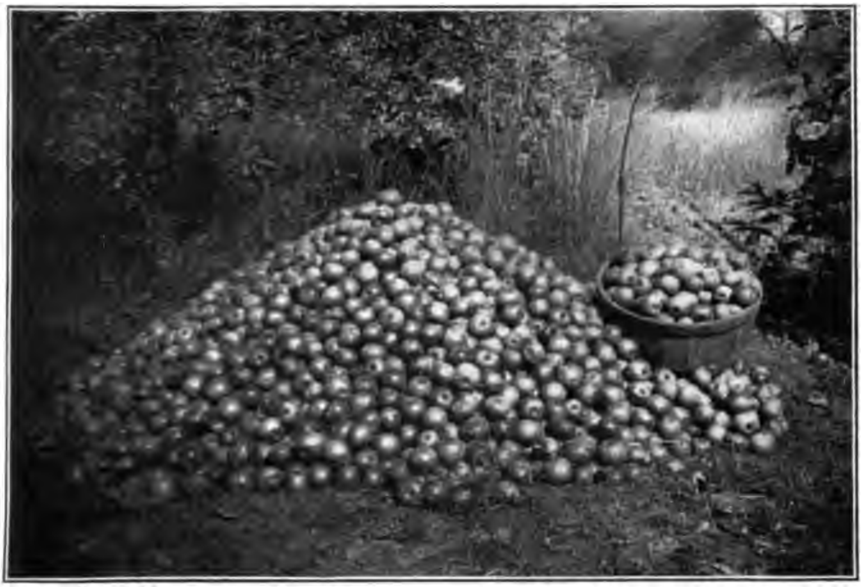

FIG. 1.—CROP OF LIMBERTWIG APPLES FROM A TREE SPRAYED THREE TIMES, BEGINNING AT THE RIGHT PERIOD. SOUND FRUIT IN PILE.

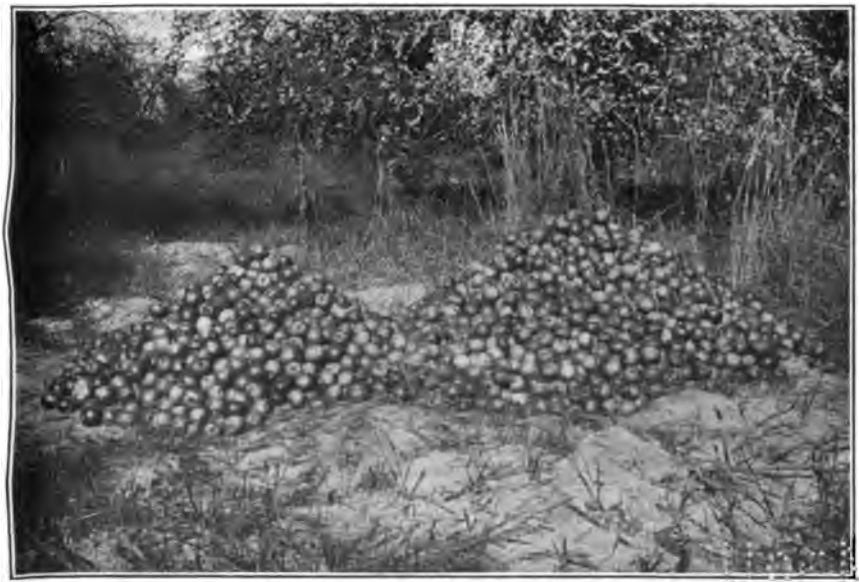

FIG. 2.—CROP OF LIMBERTWIG APPLES FROM A TREE SPRAYED THREE TIMES, BEGINNING TOO LATE. SOUND FRUIT ON LEFT.

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BUREAU OF PLANT INDUSTRY—BULLETIN NO. 145.

B. T. GALLOWAY, *Chief of Bureau.*

VEGETATION AFFECTED BY AGRICULTURE IN CENTRAL AMERICA.

BY

O. F. COOK,
Bionomist, Bureau of Plant Industry.

Issued April 10, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., January 29, 1909.

Sir: I have the honor to transmit herewith, and to recommend for publication as Bulletin No. 145 of the series of this Bureau, a manuscript entitled "Vegetation Affected by Agriculture in Central America," by Mr. O. F. Cook.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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B. P. I.—417.

VEGETATION AFFECTED BY AGRICULTURE IN CENTRAL AMERICA.

INTRODUCTION.

That climate and other natural conditions of existence have had their influences upon the development of civilization in different parts of the world has often been recognized, but relatively little study has been given to the corresponding influence of man on his environment. The two questions are in many ways inseparable, for we can hardly gain a correct idea of one without taking the other into account.

Savages who live by hunting and fishing or upon wild fruits, seeds, and honey may occupy a tropical region without seriously disturbing the previous balances of organic nature; but no careful observer of the agricultural aborigines of the Central American countries can doubt that they have had very definite influences upon their surroundings, or that influences of the same kind have been exerted for long periods of time.

Humboldt and other geographical writers have reported the existence of very diverse types of vegetation in different parts of Central America, and have proposed various geological and meteorological explanations of the distribution of the different kinds of plant life, the dense tropical forests, scattered growths of pine and oak, open grass lands, and cactus deserts. (Pl. I.)

As a matter of fact, these varied types of vegetation are not restricted to particular altitudes or to particular geological formations. There are open fire-swept grass lands near sea level and at many different elevations, and even on the upper slopes of the highest volcanic peaks. Similar wide ranges of altitudes and conditions are shared by the pines, oaks, and other trees which represent various stages of a general process of reforestation. Cacti thrive in barren places near the coast and also on the high interior plateaus.

That the geological and meteorological influences are often very important need not be denied, but their effects can be correctly estimated only when the other factors of the problem are considered, not by taking it for granted that the present conditions represent, or even approximate, the primeval state of the country. Unless we can form a definite idea of the original conditions we can not expect to judge of their influence on primitive man, nor can we determine what effects man has had upon the vegetation and other natural conditions. We need what might be called a bionomic base line, an idea of the conditions which existed before man came upon the scene, the conditions which would again supervene if the human inhabitants were withdrawn.

To invoke other than the human agencies to account for the present lack of forests in many parts of Central America is superfluous, for the destructive abilities of the Indians are everywhere in evidence. Reforestation is everywhere going on, but the Indians are also busy cutting down and burning the woody vegetation. If the burning over of the land were limited to areas ready for planting the general results would be far less disastrous, but the fires are usually allowed to spread wherever there is fuel to carry them, and large tracts of land are thus kept in a permanently barren condition. At night in the farm-clearing season the burning mountain slopes gleam with lines of light like the streets of distant cities. By day the sky is darkened and the air is heavy with smoke. That regions now so barren as the valley of Salama in central Guatemala may be artificial deserts cleared by human agency can readily be understood when the facts are viewed at first hand. The devastation which can be worked in a single corn-planting season will go far to convince the careful observer that the native methods of agriculture have wide-reaching effects.

The Central American Indians are extremely conservative people. Even those who have learned to speak Spanish and to wear European clothes still continue to follow their own primitive systems of agriculture without any appreciable change. With the exception of a limited use of wheat and of broad beans at very high elevations, no European field crops have been adopted by the Indians, much less any European methods of cultivation. Thus the present conditions may be relied upon as giving us a correct idea of the agricultural influences which have long been at work in these countries.

DIVERSE SYSTEMS OF MAIZE CULTURE.

The problem of tracing relations between agriculture and natural conditions in Central America is much simplified by the fact that one staple crop is grown over the whole area, including the humid tropical lowlands, the dry interior table-lands, and the cold, cloud-covered mountain slopes of high elevation. In spite of endless local diversities among the native inhabitants they have a general agricultural unity, for they all depend on Indian corn, sometimes to the almost complete exclusion of other kinds of food.

No one variety or type of corn thrives under so wide a range of natural conditions, but the Indians have many highly specialized varieties and many specialized methods of cultivation. These have made it possible for Indians to occupy and deforest any part of the Central American region. The large numbers and varied characters of these specializations of varieties and of cultural methods afford important evidence of the very great antiquity of the primitive agricultural civilizations in Central America.[a]

The mountainous contours of this region, together with the lack of large navigable rivers and of beasts of burden, have tended to prevent the development of great centers of civilization like those of ancient Egypt and Assyria. Neither were there any wide areas of alluvial lands adapted to permanent cultivation by the Indian methods of agriculture. The dry plateaus were the scenes of the Aztec and Inca civilizations which happened to be flourishing at the time of the Spanish conquest, but widely scattered ancient remains show that many other primitive cultures had developed and disappeared in earlier times, even in the humid lowlands.

The want of means of transportation to bring food from longer distances limited the size of native communities and prevented the simultaneous devastation of large regions, as in the Old World. A barren zone surrounding each town is a regular feature in Central America, leaving no doubt of what the results would have been if such communities could have grown to large size. (See Pl. II.) Supplies of firewood and of building timbers for Salama, Cobán, and other large towns in the interior of Guatemala are regularly carried in on the backs of Indians for two or three leagues, and often for greater distances. Indians from San Pedro Carchá, near Cobán, often plant corn over fifty miles away, in the Cahabón district. and carry the crop home on their backs.

The lack of draft animals prevented the development of the art of plowing, which might have enabled more use to be made of the land but would also have brought about a more complete and lasting denudation. The usual custom of natives of tropical countries to raise only one or two crops in each clearing appears very wasteful, but it has the advantage of making only small drafts on the fertility of the soil. The humus layer is not destroyed by fire, and the roots remain in the ground to resist erosion. Much of the vegetation survives the cutting and is ready to begin at once the process of reforestation. The corn may even be planted before the burning takes place if the rains continue too long or begin too early.

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[a] Indications of corresponding specializations in cotton culture have been noted in other papers: An Enemy of the Boll Weevil, Report 78, U. S. Dept. of Agriculture, and Cotton Culture in Guatemala, Yearbook, U. S. Dept. of Agriculture for 1904, pp. 475–488.

In a semiarid district of northwestern Guatemala the natives do not find it necessary to cut down the vegetation before burning, but simply set it on fire at the end of the dry season. The corn is planted immediately afterwards. The first light rains wet the loose surface soil and the young corn shoots up before the other plants begin to recover from the injuries of the fire. This method of burning the forest without cutting is the simplest system of corn culture thus far recorded. The alternative of cutting the forest down without burning is reported by Prof. H. Pittier as occurring in very humid districts on the west coast of Colombia, where the felled trees do not become dry enough to burn.

In many localities the crop receives no further care than the cutting, burning, planting, and harvesting. In some places it is customary to pull out the weeds; in others the weeds are not only pulled but the earth is hoed up around the stalks, as in the United States. Sometimes this is carried almost to the extent of plowing the land, for the hills are made very large. The seed is planted on little mounds of earth hoed from the sides of old hills, which are afterwards demolished and rebuilt around the young plants.

The most specialized form of corn culture is found on the higher slopes and summits of the mountains. The corn is planted every other year on narrow step-like terraces only a few feet wide. The weeds that grow up in the fallow year serve as green manure. They are chopped and covered in by hoeing down a part of the terrace next above. (See Pl. III.) The contours of many of the mountains in central Guatemala in the region of Cobulco and Quiché appear to have been smoothed down and made regular by this laborious system, which has probably been handed down from remote times. Where the rains are gentle and the soil is renewed by a friable, gradually disintegrating subsoil, this affords a practically permanent system of agriculture. There is no reforestation, but at the same time there is no destructive erosion, and the fertility of the soil is maintained by the incorporation of a regular supply of vegetable matter. European settlers have also applied it to wheat, which is raised in considerable quantities in the region of Totonicapam and Quezaltenango, where the photograph shown as Plate III was secured.

The only other method of corn culture that approaches permanence is that carried on in small gardens or yards in Indian towns. San Pedro Carchá, near Cobán, affords a notable example of a populous community living, as it were, in one continuous, permanent cornfield. The soil is deep and shows no signs of exhaustion, though it has borne annual crops of corn ever since the Spaniards explored the country, and probably for many centuries before. Thus some of the native towns in their limited areas remain quite productive spots, though their inhabitants may have reduced the surrounding country to a desert.

OCCUPATION OF CLEARED LANDS BY GRASSES.

The usual system of corn culture involves the repeated burning off of the woody growth and a resulting exposure of the soil. This causes a gradual deterioration of the crops of corn and a slower renewal of the woody vegetation. New clearings in the forest are soon covered again with bushes, and can be cut, burned, and planted again within a year or two. With each cutting the interval has to be lengthened, until finally the land becomes thoroughly occupied by coarse grasses which are not killed by fire. The Indians can then make no further use of the land for agricultural purposes.

Fires set to burn the brush off clearings are allowed to spread over the adjacent tracts of abandoned land. These accidental burnings give the grass an advantage over the woody vegetation, and the grassy areas are gradually extended. The Indians know well enough that the frequent burning over of the old cornfields keeps the land from being used again, but their interest in the future is seldom strong enough to lead to any precautions against the spreading of the fires.

Reasons have been given in another place for believing that the prairies of south Texas were kept in a treeless condition by fires in the same way as the grass-land districts of Mexico and Central America. In Texas the woody vegetation has been able to make rapid advances in recent decades because the grass is grazed and the stockmen burn the residue off every year, thus putting an end to destructive fires.[a] That frequent fires aid reforestation has also been observed by Professor Pittier on savannas in the southern part of Costa Rica, near the Pacific coast. The Indians did not make a practice of burning the savannas, which were thus left for accidental fires at long intervals, but the fires kindled every year by the civilized settlers are not severe enough to kill the bushes and trees, and the woody vegetation is now making rapid advances.

EXTINCTION OF GRASSES BY FOREST.

Under normal conditions of Indian agriculture, where burning is left to chance, the occupation of the land by the grasses is likely to continue as long as the proximity of agricultural natives insures the access of fires at the necessary intervals. If a place is abandoned and no fires are set for a sufficient period of years the grass is invaded by woody vegetation and is finally overshadowed and killed.

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[a] Cook, O. F. Change of Vegetation on the South Texas Prairies. Circular 14, Bureau of Plant Industry, U. S. Dept. of Agriculture. 1908.

In some localities it is evident that the woody vegetation may make a slow and gradual conquest, even in spite of occasional fires, if sufficient time is allowed and no new clearings are made. Many localities which are now open grass country or are covered with scattering pines, oaks, or Curatella trees are being reforested by dense tropical vegetation, wherever the opportunity is afforded by a cessation of cutting and burning. (See Pls. IV, V, and VI.)

Where the grasses are suitable for cattle and are eaten and trampled by grazing animals the fires are rendered less severe and less frequent, and there is more rapid progress toward reforestation. In districts where sheep are grazed, as in the highlands of the Department of Quiché, Guatemala, the grass is kept too short to protect the land, and a very destructive erosion can then take place. Surfaces which retained their gently sloping contours under the native system of agriculture are now becoming thickly gashed with gullies and ravines whose steep, crumbling slopes remain naked of all vegetation. The complete devastation of such areas seems likely to ensue unless the sheep are withdrawn.

BOTANICAL INDICATIONS THAT MANY FORESTS ARE OF RECENT GROWTH.

Reforestation can be traced through a succession of temporary types of vegetation, such as pines, oaks, Curatella, Acrocomia, Cecropia, Castilla, and Attalea. These are abundant in regions undergoing reforestation, but are extremely rare in virgin forests or in those sufficiently old for the tropical hard-wood trees to have grown to maturity and occupied the land, along with their attendant hosts of epiphytes and shade-tolerant undergrowth. It thus becomes evident that many of the existing forests are not permanent or primeval, but show the intermediate stages of a process of reforestation which probably requires several centuries to reach a stable condition.

While this permanent forest covering is becoming established the temporary and intermediate types are gradually crowded out and may be almost completely exterminated in districts where the forests have remained undisturbed for sufficiently long periods of time. Thus the absence of rubber trees (Castilla) and of Attalea palms from the forests along the Rio Dulce region of eastern Guatemala may be taken as evidence that this district has not been occupied by Indians for many centuries.

Such facts have to be taken into account in estimating the agricultural possibilities of a locality. Scarcity of wild rubber trees does not prove, for instance, that a place is unsuited to rubber planting, but may mean merely that there has been no agricultural occupation of that part of the country in recent times.[a] Attalea palms are described as very abundant about the ruins of Copán, in Honduras, which means that the present occupation of the country has continued for a long time. The scarcity of these palms and of wild rubber trees in the neighborhood of the extensive ruins of Palenque, in southern Mexico, would show that this region has not been occupied by Indians in recent centuries. History confirms this indication. The great Cortez himself passed close to Palenque on his way to Honduras. Though searching for Indian cities, he found only uninhabited forests and appears not to have learned that the ruins existed.

PREVIOUS DENUDATION SHOWN BY ABSENCE OF UNDERGROWTH PALMS.

Central America is the home of many species of Chamaedorea and other small palms which live among the undergrowth in the shady depths of the forests. Nevertheless, many localities affording conditions apparently suitable for these palms are without any representatives of the group. The undergrowth palms remain abundant only in regions which have not been completely deforested for agricultural purposes, and especially in districts too mountainous and broken for agricultural use.

Though palms are generally able to grow under a rather wide range of conditions, they can spread only slowly, for their seeds are large and appear to have no ready means of transportation except the wood pigeons, which are exterminated with the forests. Further evidence that the palms spread very slowly is to be found in the fact that nearly all of the native species appear to be quite narrowly localized. The Costa Rican species are not known from Guatemala, nor the Guatemalan species from Mexico, except along the border.

PREVIOUS DENUDATION SHOWN BY ABSENCE OF HUMUS-INHABITING ARTHROPODS.

Localities which contain remnants of ancient forests can be recognized by the presence of complete faunas of humus-inhabiting forest animals, such as the millipeds and centipeds, and some of the lower orders of insects and arachnids. In districts which are frequently cleared by cutting and burning many of the humus-inhabiting groups are exterminated. Even if they escape the fire they are unable to resist the exposure to the heat, sunlight, and dryness of cultivated lands. As long as the surface soil retains its humus and remains loose and pervious to water some of the smaller subterranean forms will persist, but when denudation is complete or when the soil becomes sticky and impervious the humus-inhabiting types entirely disappear, as in many of the tenacious "gumbo" soils of the Texas prairies.

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[a] Cook, O. F. Culture of the Central American Rubber Tree. Bulletin 49, Bureau of Plant Industry, U. S. Dept. of Agriculture. 1903.

Many forested places in Central America which now afford conditions favorable for these humus-loving animals are occupied by small and incomplete faunas. This shows that the period of reforestation has not been long enough to permit these sedentary, slow-moving creatures to spread again over the reforested areas. Thus, in the valley of Ocosingo in southern Mexico are many such tracts of new forest in which the humus fauna is still very poorly represented. Nevertheless, the woody growth which now crowns the extensive ruins of Tanina, a few miles from Ocosingo, shelters a rich fauna of humus-inhabiting types. It seems impossible to account for the presence of such a fauna except by supposing that there was a complete and long-continued reforestation of the district after the ruins were built, but before the present population came in and cleared the land anew.

Of the periods of time required for such changes to be accomplished only rude estimates are possible in the present state of our knowledge. A thousand years appears a small allowance for the complete reforestation of a thoroughly denuded region and for the spread of the humus-inhabiting organisms over the reforested country. The survival of the humus-inhabiting animals on the ruin-covered hill is hardly to be considered possible, for the pyramids and chambered buildings which covered the summit, as well as large areas of the elaborately terraced approaches, appear to have been faced all over with cement.

Populous Indian communities, such as the builders of these ruins must have formed, not only cut down all the accessible forests to plant corn, but keep the surrounding country stripped of woody growth to supply the never-ceasing demand for fuel. Long after all the lands for many miles around are exhausted the community may persist, so great is the disinclination of the Indian to leave the place where his forefathers have lived. Thus the abandonment and reforestation of a district has always to be thought of as a slow and gradual process, requiring much more time than would be needed if the vegetation could be left entirely alone. In like manner it must be considered that a long period is required for the reoccupation and development of a new native culture in a district in which the forest growth has been allowed to become fully restored.

Of the sudden movements of large bodies of population as results of wars and conquests there are no indications in the habits and traditions of the peaceable, sedentary agricultural natives of this region. Each successive occupation is to be thought of as slowly growing into a new region and as slowly dying out as the agricultural possibilities of the land became exhausted. Thus, if no time were lost in the reoccupation of a region like that of Ocosingo as soon as reforestation had become complete and the humus-inhabiting organisms had regained their natural distribution, the intervals between successive occupations are not likely to be less than two or three thousand years, and might easily be greater.

DESERT VEGETATION IN DENUDED AREAS.

The Cahabón district of eastern Guatemala affords an excellent example of an artificially cleared area surrounded by larger tracts of forested country. The greater length of the dry season in Cahabón is a fact familiarly recognized by residents and proved by the presence of cocoanut palms and other types of vegetation which do not thrive in continuously humid regions away from the seacoast. The traveler who visits Cahabón in the spring months may have even more vivid evidence, for he may see day after day showers of rain falling a few miles away before any come to Cahabón.

The contrast with the neighboring forested districts is strengthened, no doubt, by the somewhat lower elevation and higher temperature of the Cahabón region. Yet forests would soon cover the whole district if agriculture ceased, and would certainly affect the factors of temperature and humidity by which the rainfall is controlled.

A similar instance is found on the eastern slope of Costa Rica. If the testimony of intelligent men who settled in this region a quarter of a century ago is to be believed, the rainfall was then distributed through the entire year, as it still is in adjacent districts where the forests remain. But in the narrow belt of cleared lands along the railroad that climbs the slope, the dry seasons have become longer and longer. In recent years destructive droughts have occurred and severe windstorms, also quite unknown before the forests were cut away.

That many localities in the Old World which once were occupied by populous civilizations are now abandoned deserts has long been known to historians and archæologists. Some writers have held that such changes could only be explained by supposing that denudation has changed the climate and caused a general reduction of the rainfall. The facts observed in Central America show that denudation may bring about artificial desert conditions, even where the total rainfall continues to be sufficient for the growth of forests. It is only necessary that the vegetation be cleared away and that the dry season be lengthened.

The exclusion of the more delicate moisture-loving types of plant and animal life from denuded regions is sufficiently explained by the greater dryness of the atmosphere and the lengthening of the dry season, conditions which are evidently intensified by the exposure of the earth to the sun. Denudation allows the rain water to run off at once, and thus reduces the amount of moisture available for evaporation into the atmosphere. At the same time the relative humidity of the air is decreased through the greater radiation of heat from the exposed, sun-baked earth. The earlier and later rains are diminished and the dry season is lengthened until only the drought-resistant types of vegetation are able to survive. Even if there were no change at all in the amount of rainfall, changes in the distribution of the rainfall would have serious effects on the vegetation.

On large continental land masses where there is an extensive circulation of the atmosphere exposures of the bare earth may appear to have no very definite effect upon the climate, but in Central America the effects of local conditions are often readily appreciable. The regular alternation of land and sea breezes within a few hours does not compel any general circulation of the atmosphere, but only slight local displacements. Precipitation follows relatively small fluctuations of temperature and is the more readily and obviously influenced by local conditions. A column of heated air rising from a denuded district can often be seen to absorb the clouds which drift over from a neighboring forested area. A striking example of this phenomenon[a] can be seen in the spring months from the crest of the mountain which overlooks the valley of Salama, on the road to Rabinal. (See Pl. VII.)

PREVIOUS OCCUPATIONS SHOWN BY ARCHÆOLOGICAL REMAINS.

Many localities which are now occupied by apparently virgin forests are shown by archæological remains to be regions of reforestation. Thus in the Senahu-Cahabón district of Alta Vera Paz relics of two or three very different types of primitive civilizations indicate that as many ancient populations have occupied successively the same areas which are now being cleared anew by the coffee planters as though for the first time.

It does not yet appear that any considerable region of forest has been explored in Central America without finding similar evidence that the present forests are not truly virgin growth. Even in extremely humid and insalubrious lowlands of the Atlantic slope of Costa Rica many relics of ancient civilizations have been uncovered in clearing away the heavy tropical forests to make banana plantations. The same has recently been found to be true of the uninhabited coast regions of eastern Guatemala.

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[a] A similar effect is reported by Darwin from Brazil (see Voyage of the *Beagle*, Chap. II), but is described as occurring near sunset, whereas it may be seen in Guatemala during several hours of the day. The clouds are not collected about elevated summits, but float higher in the air.

It is not probable that more than a small proportion of the native tribes which have inhabited the Central American region were builders of stone structures or other permanent monuments by which ancient occupations could be proved. The likelihood that many tribes might pass without leaving any permanent evidence of their existence makes it the more remarkable that all parts of Central America have in one prehistoric age or another been the scenes of primitive agricultural civilizations sufficiently advanced to work in stone, or at least to pile up terraces or earthworks of regular form. Some of the more barbarous tribes might occupy a region for thousands of years and yet leave no traces other than the fragments of broken pottery. These fragments are so abundant and so generally distributed in Central America that they appear as a regular constituent of alluvial soils and surface deposits.

But even the pottery may not mark the limits of primitive civilization, for the Central American pottery is not glazed, and after a sufficient lapse of time it crumbles away. A more striking evidence of antiquity could scarcely be imagined than the gradual crumbling down of large earthenware pots left by prehistoric man in dry caves of eastern Guatemala. Of the skeletons beside the pots only the teeth remain, and of the pots themselves only the rims or little circular mounds of earth. We can not know how long it has taken the pottery to crumble, but we can at least contrast the condition of these decayed pots with other pieces of pottery placed in caves of the same district in later prehistoric ages, which still appear fresh and new, as though recently burned. And yet the bones beside these apparently new pots have also crumbled nearly to dust, and there has been time for the surrounding country to be occupied with old forests of hard-wood trees, like true virgin growth.

PREHISTORIC AGRICULTURE SHOWN BY TERRACING OF LAND.

Terracing of the land shows that agriculture was extensively practiced in former times in regions now unoccupied. Two principal forms of prehistoric stone terraces, built evidently for agricultural purposes, may be recognized in the Central American region, in addition to the narrow terraces of earth described in a previous section. There are (1) narrow, high terraces to hold drainage water and prevent erosion in the narrow valleys or on steep slopes of mountains and (2) broad, low terraces apparently leveled to keep rain water from running off rather than to apply irrigation.

Terraces of the first type are frequently met with in the heavily forested region in eastern Guatemala. Similar terraces are used at the present time in the denuded mountains of northwestern Guatemala, between Santo Tomás and Jacaltenango. Terraces of the second type cover many square miles of unoccupied land in the semiarid plateau region of the Mexican State of Chiapas, between the Guatemalan boundary and Comitán, as well as between Comitán and Ocosingo. This terraced region is now covered partly by fire-swept grass lands and partly by scattered growths of pines and oaks, where the fires are less severe. In some localities to the east of Comitán the terraced lands are now used for agriculture, but the present occupation is obviously recent and has nothing to do with the building of the terraces. Indeed, it is difficult to convince the natives that the terraces are not natural features of the country.

The motive of the prehistoric people in building these broad terraces is not easy to understand unless they are considered as a method of dry farming. The walls are only a few feet high, though the area inclosed may be several acres in extent. Even without the terraces the land would often appear quite level, the slopes being extremely gentle. This makes it quite improbable that the terraces had the object of avoiding erosion, like the system of terracing followed in our Southeastern States. There is also no indication that they were intended to impound running water or that artificial irrigation was applied. The walls do not rise above the level of the land inclosed. The probability is that the complete leveling of the land was found useful to prevent the running off of any of the rather slight rainfall which comes to these semiarid districts. While the terraces are not high, the walls are often half a mile or more in length. The leveling of the land must have required vastly more labor than the building of the walls, but the work may have been done gradually if a regular practice of hoeing the earth toward the wall were followed.

EFFECTS OF AGRICULTURE ON FORMS OF EROSION.

That the ancient occupations of the humid mountain regions of eastern Guatemala by agricultural civilizations were very prolonged or were repeated in several prehistoric ages is indicated by the very severe erosion which this region has suffered. It is not likely that such deeply dissected contours would have been formed if the country had not been kept in a denuded condition for long periods of time.

There is practically no erosion at all on slopes covered with dense tropical forest. The soil is never loosened by frost, but is held in place by the matted roots of trees and thatched over with a compact layer of fallen leaves. On the steep slopes this covering sheds the rain so effectively that the subsoil often remains permanently dry and dusty.

The storage of water by the forest on these very steep slopes is largely limited to the wetting of the humus layer, which may be only a few inches thick. If the rains cease for only two or three weeks this slender supply of water is exhausted. The plants wilt and shrivel up as though suffering from a prolonged drought. Slopes too steep for any rain to penetrate are often occupied by desert types of vegetation, though immediately surrounded by the vegetation appropriate to the general humidity of the region.

The water of the torrents that gather from the forested slopes is still clean, even after heavy rains, or is made only slightly milky by the washings of the leaves. Only the erosion of the streams loosens any solid matter. After the forest has been cut and the dry brush has been burned off the loose surface soil is left fully exposed. More erosion can then take place in a single season than would be possible in many centuries of undisturbed forest growth.

DISTRIBUTION OF PINES AND OAKS DETERMINED BY CLEARING OF LAND.

The presence of open forests of pines and oaks is not determined by altitude. Pine forests occur under a wide variety of conditions and at all elevations. They extend from near sea level in eastern Guatemala through the dry and elevated interior to the tops of the highest volcanoes. The same may be said of the oaks, except that they do not appear to ascend as high as the pines. Wherever there are grassy, fire-ravaged tracts to be occupied, the pines and oaks appear to be able to establish themselves if sufficient time is allowed. About Lake Yzabal, in eastern Guatemala, there are pine forests very nearly at the level of the sea. In the Palenque district of southern Mexico the oaks descend in a similar manner. Oaks also grow close to the seashore in the district of Guanacaste, on the Pacific side of Costa Rica, as reported by Professor Pittier.

The natural habitats of the several species of pines and of the very numerous species of oaks of the Central American region are probably to be found on the dry exposed crags and summits of the mountains. These are the only places where these slow-growing types would be able to maintain footholds if they had to meet the competition of the tropical vegetation without the help of men and fires. It is this competition of the more luxuriant tropical types of vegetation that limits the spread of the pines and oaks in Central America, rather than any particular requirements of altitudes, temperatures, or other climatic conditions.

Ability to resist fire is the characteristic that enables the pines to establish themselves in open grass lands. Young pines with the growing bud surrounded by many green needles can survive fires that kill seedlings of other plants. As the trees grow larger they are protected by a thickened bark which is a very poor conductor of heat and not readily combustible. Nevertheless, the survival of the pines depends on the chance of frequent fires which prevent the accumulation of grass in large quantities. With grass enough to burn, even large pines may be killed by fire and the pine forest driven back from areas it has already occupied. (See Pl. VIII.) In this way a species of wire-grass (Epicampes) is destroying forests of alders and pines on the upper slopes of the Vulcan de Agua in Guatemala. Before the access of fires this grass appears to have been confined to the crater and to the very dry upper slopes, where the pine trees are small and scattering. Now that the belts of humid forests lower down have been broken by clearings the grass has the assistance of fire and is destroying the trees with increasing rapidity.

There are no springs or streams on the upper slopes of the volcano, so that the grass is not pastured. Its long wiry stems and leaves accumulate until there are quantities of fuel sufficient to kill large trees and to drive back the forest for long distances at each conflagration. The lower the grass comes the more luxuriant its growth and the more destructive the next fire. This will continue as long as the grass is ungrazed or care is not taken to burn the grass every year in order to prevent the accumulation of dangerous quantities of fuel.

The roots of this grass are well protected from the fire by masses of the closely packed stems. These tufts remain wet while everything else is thoroughly dried. Except in rainy weather, no water can be obtained from the extremely coarse and loose volcanic ashes and rocks of which the upper parts of the mountain are composed. Weldenia and other native plants show striking adaptations for drought resistance. Even the alder has a remarkably thick, cheesy bark, which doubtless serves for the storage of additional supplies of water.

BURIED ROOTS SHOW FORMER EXTENSION OF PINES.

In eastern Guatemala the secondary character of supposedly primeval forests is shown by the fact that pine roots are often found in the ground in districts from which living pines have been completely driven out by the more luxuriant tropical types of vegetation. The Indians dig up the pitchy roots of the extinct pines and use them for torches. Such roots are found in the alluvial bottom lands of the Polochic Valley, near Panzós, almost at sea level, and also in the coffee district to the north of Senahu at altitudes of about 3,000 feet and upward. Both localities are distant several miles from any living forests of pine.

It is easy to understand that pines were more abundant in this region in former times than at present, because the native population is known to have greatly decreased since the arrival of Europeans. Greater numbers of Indians would mean the clearing of a larger proportion of the land and larger opportunities for the spread of the pines.

DENUDED AREAS NOT NATURALLY UNSUITED TO FORESTS.

The districts now most deficient in forest covering and with the artificial desert conditions most intensified, are not those of broken contours and steep declivities, but are usually the level areas and gentle slopes—the places naturally well suited to support heavy forest growth. But they are also the locations which the Indians would always prefer as having the most fruitful soil and being the easiest to clear for planting. Wherever such level spots or gentle slopes in denuded districts are still fertile they are highly prized by the Indians, who even build walls around them to clear the land of stones and keep out the cattle. Many of these small, isolated, walled-in fields can be seen on the spurs of the hills about Salama. Agricultural motives may also account for much of the stone inclosures and terraces which cover the upper slopes of ruin-crowned mountains, like that above Rabinal in central Guatemala. Unlike the regular walls and courts on the summit of the mountain, these lower terraces have no regular plan and appear to have been built to level the earth and free it from stones. The Indians still plant these terraces with corn, though the lower slopes of the mountain are now barren, like much of the adjacent country.

FORESTS IN ROCKY AND PRECIPITOUS PLACES.

In no part of Central America do the natural conditions exclude the growth of trees. Localities too remote from water or too inaccessible, rocky, or precipitous to serve any agricultural purpose are invariably supplied with forest growth. In inhabited districts where there is a scarcity of lands suitable for corn planting, extremely rocky and precipitous places are cleared and burned over for the sake of the single crop of corn that can be grown from the little soil which has accumulated in the interstices of the rocks. The reforestation of such places takes place with extreme slowness, for although the vegetation does not consist of grass it becomes thoroughly dried every year and is likely to burn up, even without being cut. In some districts, as about Nenton in the Department of Huehuetenango, Guatemala, the Indians do not take the trouble to cut the brush, but simply send the fire through it and plant their corn among the dead poles, as already noted among the native systems of corn culture.

The fact that forests are still to be found in the most unfavorable places shows that the rainfall is sufficient for the growth of trees throughout the Central American region. Differences of natural conditions can influence only the factor of time, but could not prevent an ultimate reforestation. How many centuries or millenniums would be required to reclothe with forests such deserts as these of the valley of Salama is a question in which many considerations of soils, drainage, temperature, and rainfall would enter, but it seems superfluous to doubt that the result would be finally attained, if there were no men to cut down the trees and kindle fires.

SUMMARY.

The distribution of grass lands and of open forests of pines and oaks in Central America does not depend primarily upon natural conditions, such as contours, elevations, soils, or rainfalls, but is chiefly determined by previous occupations of the land by agricultural natives. Pines and oaks represent stages of the process of reforestation; they descend even to sea level to occupy open country where the fires exclude other less hardy vegetation. The former existence of pines in regions now occupied by luxuriant tropical forest is often shown by the persistence of the pine roots in the ground.

The driest and most sterile localities, those too forbidding for human occupation, have retained their forest growth, scarcely excepting sheer precipices and exposures of bare rocks. The regions which are now treeless and barren or covered only with grass are those naturally well suited for the growth of forests, for the formation of fertile soil, and for human occupation. Indications of prehistoric agriculture are found in all the denuded areas, as well as in other regions now covered with forests.

Truly virgin forests seem not to exist in Central America. Relics of ancient agricultural occupations seem nowhere to be lacking, even in regions now entirely uninhabited, in dense forests as well as in open desert regions.

The abundance of rubber and other temporary types of trees and the absence of humus-inhabiting arthropods and forest palms enable regions of recent reforestation to be distinguished from forests of older growth.

Facts of several different kinds thus support the conclusion that the Central American region had a continuous forest covering before the advent of agricultural man. If human interference were withdrawn the normal growth of the vegetation would again cover the Central American region with dense and continuous forests.

Repeated clearing and burning of the woody vegetation for the planting of corn allows the land to become overgrown with coarse grasses. The burning over of the grass lands prevents the growth of young trees, and may even drive back and destroy adjacent forest. As long as the burning continues the grasses remain, but with the cessation of fires the forest growth is renewed. Such processes of alternating denudations and reforestations have evidently continued in Central America for long periods of time.

It becomes evident that the simple operations of primitive agriculture, the mere cutting and burning of the natural vegetation, can induce desert conditions, even in naturally forested tropical regions. Though the effects of human activities may not be so direct or so obvious in temperate climates as in tropical countries, it is well to be aware of the fact that natural conditions can be profoundly altered by human agencies.

Apart from dangers of war or pestilence to which the ancient communities of Central America may have been exposed, their existence was definitely limited by methods of agriculture which denuded the country of its forests and destroyed the fertility of the soil. Civilization is at an end when an agricultural country ceases to be adapted to agriculture. To recognize these natural limitations of the primitive civilizations of Central America should make us more careful to appreciate and to correct the harmful tendencies of some of our own systems of agriculture.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. *Frontispiece.*—Denuded lands occupied by cactus deserts, near El Rancho, eastern Guatemala.

PLATE II. Denudation and erosion at Cahabón, in eastern Guatemala, a region naturally covered with heavy forests.

PLATE III. Mountain sides terraced for corn and wheat, district of Quezaltenango, western Guatemala.

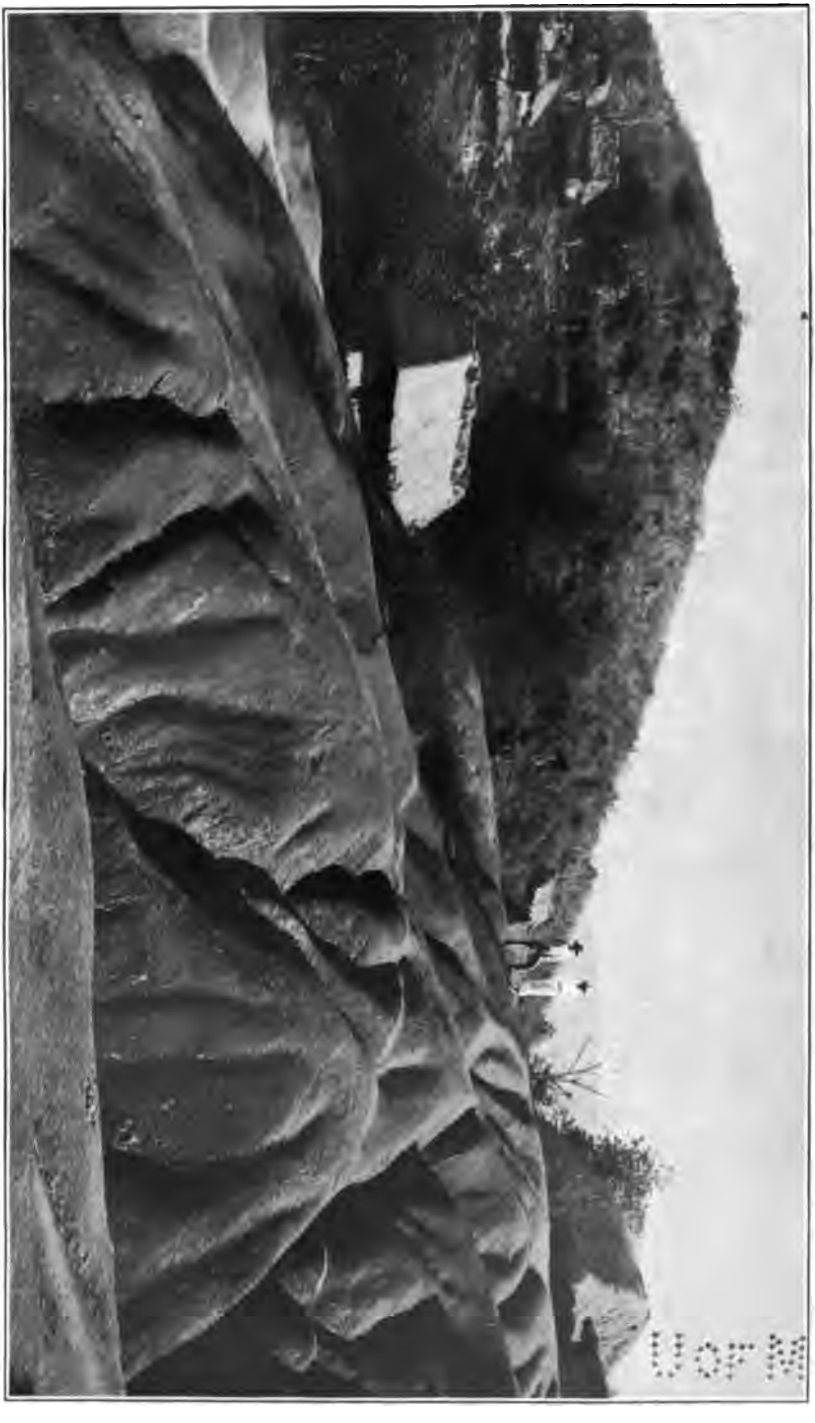
PLATE IV. Denuded mountains in eastern Guatemala partially reforested with scattering pines; tropical vegetation in the deeper valleys.

PLATE V. Valley in open pine forest with advancing growth of tropical trees, Cahabón district, eastern Guatemala.

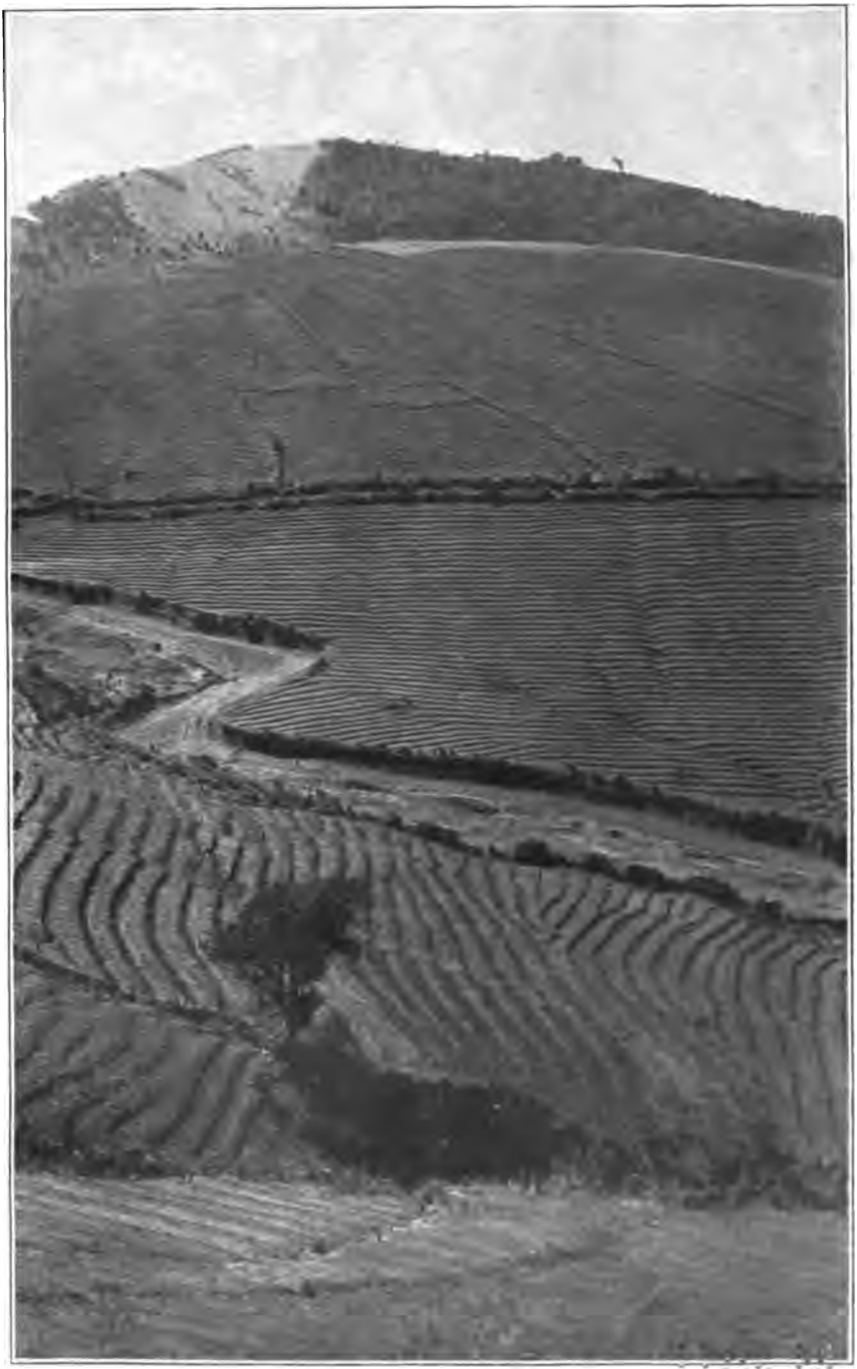
PLATE VI. Tropical growth in a reforested valley like that shown in Plate V; dense shade excludes the grass and puts an end to fires.

PLATE VII. Denuded, fire-swept slopes above the valley of Salama, Guatemala, reforested with scattering pines. The clouds are over the oak-forested mountains in the distance. A column of heated air rising from a denuded district can often be seen to absorb the clouds which drift over from a neighboring forested area.

PLATE VIII. Fig. 1.—Pine forest and bunch-grass on the upper slopes of Vulcan de Agua, Guatemala. With grass enough to burn, even large pines may be killed by fire and the forests driven back from areas they have already reoccupied. Fig. 2.—Pine forest inside the rim of the crater of Vulcan de Agua, Guatemala.



DENUDATION AND EROSION AT CAHABÓN, EASTERN GUATEMALA, A REGION NATURALLY COVERED WITH HEAVY FORESTS.



MOUNTAIN SIDES TERRACED FOR CORN AND WHEAT, DISTRICT OF QUEZALTENANGO, WESTERN GUATEMALA.

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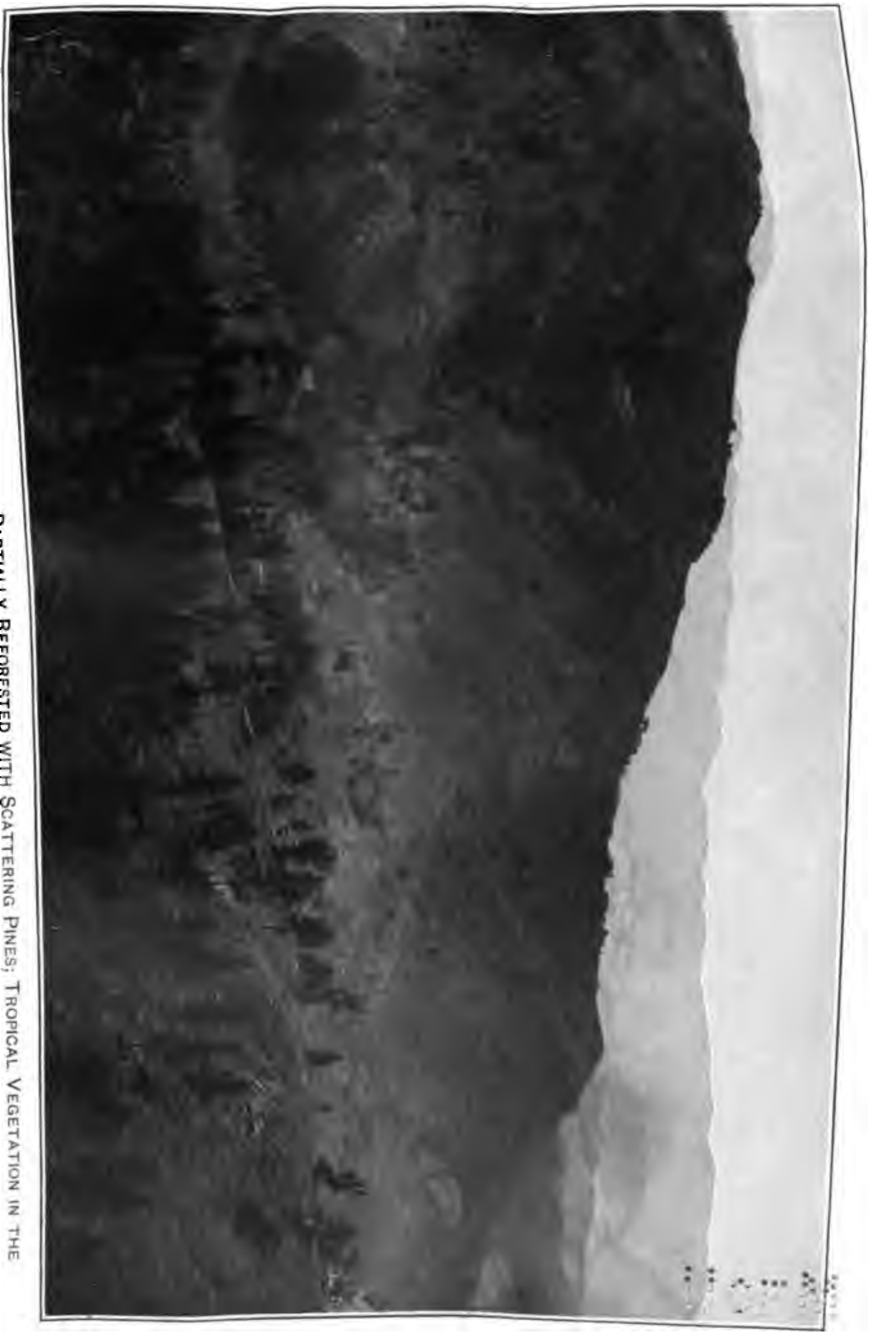
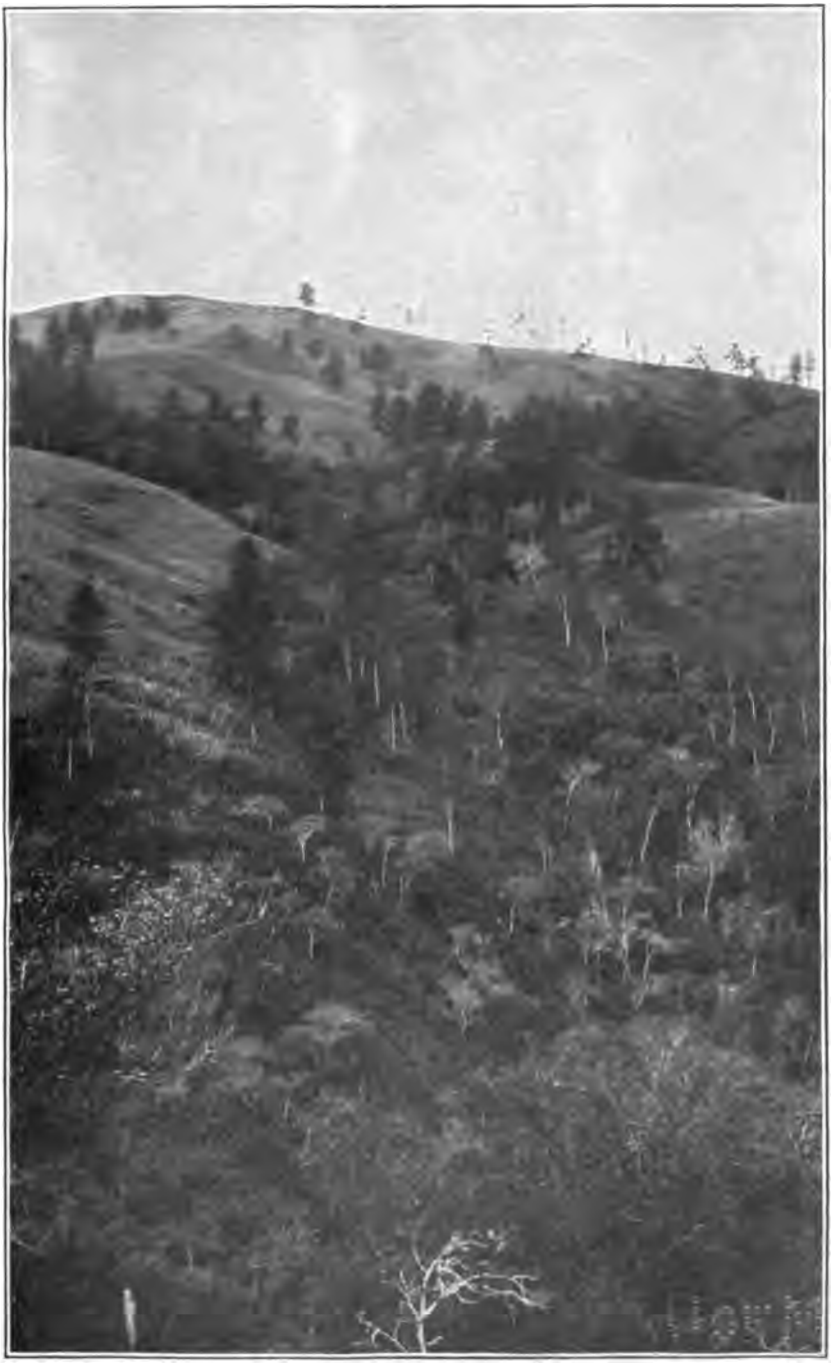


DENUDED MOUNTAINS IN EASTERN GUATEMALA PARTIALLY REFORESTED WITH SCATTERING PINES; TROPICAL VEGETATION IN THE DEEPER VALLEYS.



VALLEY IN OPEN PINE FOREST WITH ADVANCING GROWTH OF TROPICAL TREES, CAHABÓN DISTRICT, EASTERN GUATEMALA.

TROPICAL GROWTH IN A REFORESTED VALLEY LIKE THAT SHOWN IN PLATE V; DENSE SHADE EXCLUDES THE GRASS AND PUTS AN END TO FIRES.

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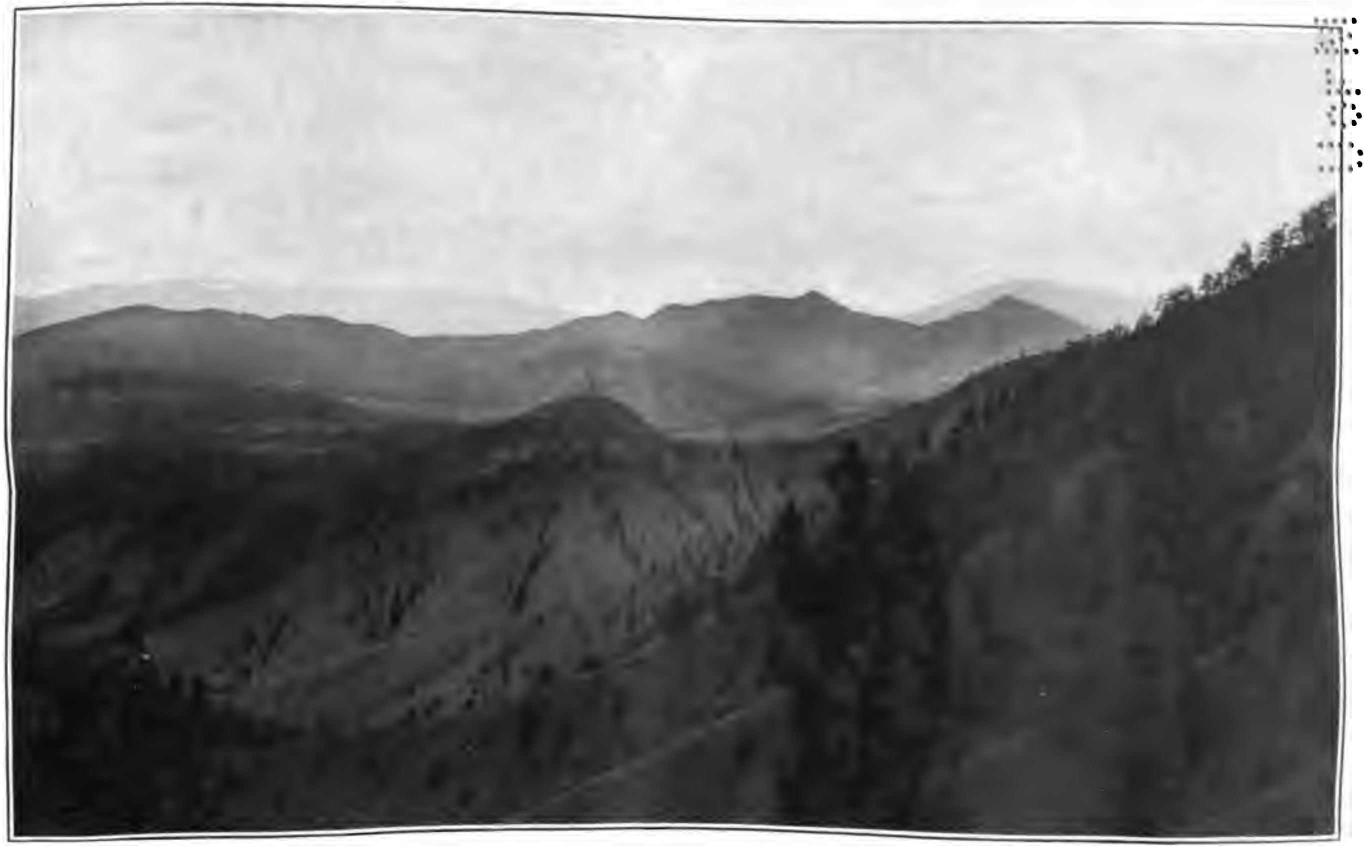

DENUDED, FIRE-SWEPT SLOPES ABOVE THE VALLEY OF SALAMA, GUATEMALA, REFORESTED WITH SCATTERING PINES.

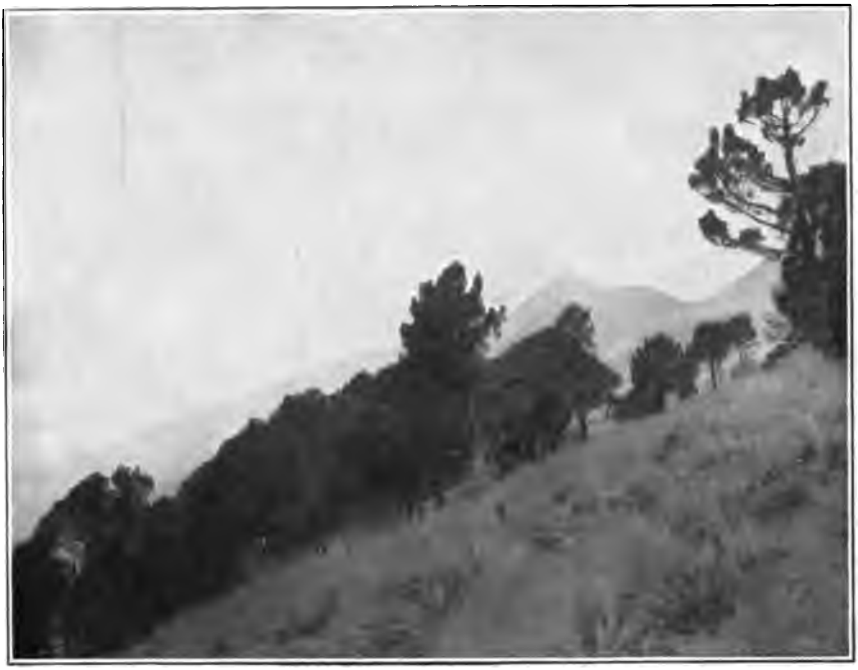

FIG. 1.—PINE FOREST AND BUNCH-GRASS ON THE UPPER SLOPES OF VULCAN DE AGUA, GUATEMALA.

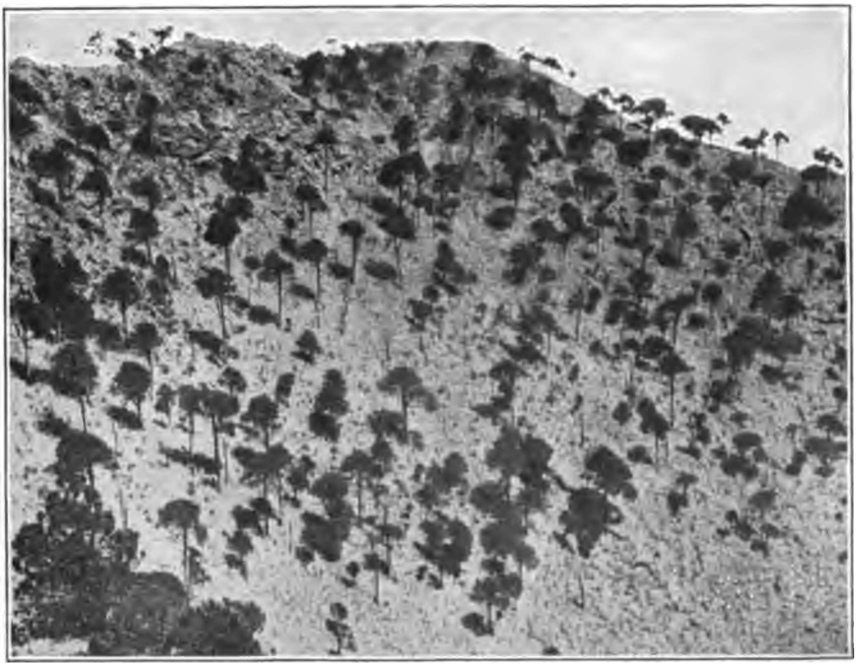

FIG. 2.—PINE FOREST INSIDE THE RIM OF THE CRATER OF VULCAN DE AGUA, GUATEMALA

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 146.

B. T. GALLOWAY, *Chief of Bureau.*

UNIV. OF MICH.
JUN 8 1909

THE SUPERIORITY OF LINE BREEDING OVER NARROW BREEDING.

BY

O. F. COOK,
BIONOMIST, BUREAU OF PLANT INDUSTRY.

ISSUED APRIL 29, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of Chief of Bureau,
Washington, D. C., February 25, 1909.

Sir: I have the honor to transmit herewith a paper entitled "The Superiority of Line Breeding over Narrow Breeding," by Mr. O. F. Cook, and recommend its publication as Bulletin No. 146 of the special series of the Bureau of Plant Industry.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE SUPERIORITY OF LINE BREEDING OVER NARROW BREEDING.

INTRODUCTION.

None of the applications of the science of evolution to the art of breeding has been the subject of so much study, experiment, and discussion as the relative merits of inbreeding and cross-breeding. Nevertheless, opinions remain as discordant as ever, for some experiments appear to indicate that cross-breeding is better than inbreeding, while other experiments seem to show quite as definitely that inbreeding is better than crossing.

Experiments are our means of securing answers to scientific questions. When experiments appear to give contradictory or equivocal answers we know that we have not asked our questions in the right way. We are warned that there are more differences among our facts than our theories have recognized. We must find another point of view more favorable for the interpretation of the facts.

Some breeders have generalized upon the results of their own experiments and ignored the contrary results reported elsewhere. Others have taken a broader view of the subject and have sought to compromise the issue between inbreeding and cross-breeding by assuming that the different types of plants or animals are so differently constituted that inbreeding represents the normal method for some species, cross-breeding for others. The effect of this opinion has been merely to postpone the issue, not to determine it, for we can not avoid thinking of reproduction as a physiological process or fail to ask the question why members of one species should appear to thrive best by inbreeding and members of another species by crossing.

It is the purpose of this paper to point out some of the sources of confusion which have interfered with definite scientific solutions of problems of breeding, and to indicate a point of view from which contradictory opinions can be reconciled. As soon as it becomes possible to recognize physiological relations behind the apparently contradictory evidence the subject is opened to new methods of investigation.

THREE PRINCIPAL TYPES OF REPRODUCTION.

I. Broad breeding.
II. Narrow breeding.
III. Line breeding:
  (*a*) In-and-in breeding.
  (*b*) Self-fertilization.
  (*c*) Parthenogenesis.
  (*d*) Vegetative propagation.

Some of the difficulties in the study of breeding have come from the fact that three principal types or methods of reproduction have been under consideration, though only two have been formally recognized. Many writers on breeding could be charged with the error of reasoning called by logicians "the undistributed middle." They have applied the same names to conditions essentially different.

The term "cross-breeding" has been applied to the condition of free interbreeding among the members of large groups, such as species in nature, as well as to the mating of individuals representing small, close-bred varieties, or even to the crossing of closely related individuals of the same strain when such crosses are being contrasted with self-fertilization.

The term "inbreeding" has also been used for a wide series of conditions. It is commonly applied to the self-fertilization of plants by their own pollen as well as to in-and-in breeding among closely related members of the same family group, and even to the more miscellaneous form of close breeding found in a flock of sheep or poultry when no "new blood" is brought in.

The meanings of the two terms remain distinct only at the extreme ends of the series of facts to which they are applied, and widely overlap in the middle. Whether a particular condition of descent is to be described as inbreeding or as cross-breeding is usually allowed to depend entirely on the particular instances in hand. The same case may be called "inbreeding" if the author wishes to compare it with another in which there is wider crossing, or it may be called "cross-breeding" if it is to be compared with a smaller amount of crossing. Thus the same word may describe different conditions, or different words the same condition.

For many purposes of comparison the use of the words "cross-breeding" and "inbreeding" in these merely relative senses is convenient and entirely proper, but it leads to serious confusion when we attempt to distinguish the underlying factors. This confusion can be avoided by choosing other words to which more definite meanings can be attached. For the purposes of the present explanation it seems desirable to recognize three principal conditions or methods of reproduction, which may be characterized as follows:

Broad breeding is the condition of descent found in natural species, which consist of millions of diverse individuals freely interbreeding with each other, so that the vast numbers of lines of descent of the species are joined into a broad network.[a]

Narrow breeding is the condition of descent found in carefully selected varieties, consisting of relatively small numbers of closely similar individuals interbreeding with each other to form a narrow network of descent.

Line breeding is the condition of descent found in strains descended from single individuals propagated without interbreeding with other lines of descent, so that no network is formed.

The comparison of descent in normal broad-bred species to a network or fabric helps to distinguish between the two types of restricted descent. The usual process of selection to secure uniformity in the expression of characters in a sexually reproduced group is called "narrow breeding" because it reduces or subdivides the network of the species to narrow strands. When descent is still further restricted so that lines of descent from particular individuals are kept separate we have the condition called "line breeding."

Four forms of line breeding are to be considered in later sections: Vegetative propagation, parthenogenesis, self-fertilization, and in-and-in breeding.

Broad breeding might be described as a wide and indiscriminate form of cross-breeding, and line breeding as the strictest form of inbreeding. Narrow breeding is the intermediate condition which many authors have called "cross-breeding" and many others "inbreeding." The mistake has been to suppose that this intermediate condition of narrow breeding is the same as one or the other of the extremes of the series. Narrow breeding is in reality quite as different from broad breeding and from line breeding as these are from each other, and in some very important respects more different, as will be shown in the later sections.

EFFECTS OF RESTRICTION OF DESCENT.

Broad breeding is the normal condition of reproduction in natural species, the condition in which normal evolution takes place. The lines of descent of any individual if traced backward are found to diverge more and more to connect with a vast number of ancestors, and eventually with all the members of the group, for the network is continuous. It is this continuous network of descent that makes a species a definite biological entity and not a mere collection of similar individuals. The absence of any restriction of interbreeding among the members of a species allows the lines of descent to be joined into a broad network. Restriction of descent means a limitation of the number of ancestors and of lines of descent, so that only a narrow network, or none at all, can be formed.

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[a] Cook, O. F. The Vital Fabric of Descent. Proceedings, Washington Academy of Sciences, vol. 7, pp. 301–323. 1906.

If we recognize broad breeding as the natural condition in which organisms thrive and species make evolutionary progress, it is easy to understand that persistent narrow breeding may interfere with such progress or cause degeneration in characters or qualities already attained. Evolution, instead of being brought about by restriction of descent, as some have supposed, is actually hindered and finally undone.[a]

There is no evidence to show that any form of restricted descent, either to narrow networks or to simple individual lines, is an advantage to a group of organisms in the sense that it enables them to produce stronger individuals in larger numbers. The evidence all tends to show that restriction of descent results, sooner or later, in degeneration and extinction. Nevertheless, different methods of restricting descent may bring very different results, which the distinction between narrow breeding and line breeding helps us to recognize. If biological phenomena were governed by rules of logic it could be reasoned that line breeding must be more promptly injurious than narrow breeding, because it is narrower than narrow breeding. The actual results often show the contrary. One line of descent often proves to be stronger than a few lines. Line breeding by self-fertilization or in-and-in breeding is often superior to more indiscriminate breeding among the descendants of a few ancestors. After distinguishing the three general types or conditions of reproduction, it becomes possible to consider that line breeding is often superior to narrow breeding, without any need of supposing that line breeding is ever superior to broad breeding, in maintaining higher degrees of vigor and fertility.

Vigor and fertility, though of fundamental biological and evolutionary importance, are not the only forms of superiority that the breeder takes into account, for many highly prized characteristics of domesticated varieties, such as seedlessness, are in the nature of biological degenerations artificially preserved for the special uses of man. We think of even a seedless variety as fertile if it yields us good quantities of a useful product, though it has to be reckoned as completely sterile in the biological sense. But whether we wish in particular cases to preserve the biological superiority of our varieties or are willing to sacrifice vigor or fertility to special purposes of use, we need to recognize the underlying biological principles. We can then understand that different kinds of improvement are to be sought in different directions and by different methods.

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[a] Cook, O. F. Methods and Causes of Evolution. Bulletin 136, Bureau of Plant Industry, U. S. Department of Agriculture. 1908. See also Aspects of Kinetic Evolution, in Proceedings, Washington Academy of Sciences, vol. 8, p. 197, 1907.

AGRICULTURAL IMPROVEMENT BY INCREASE OF UNIFORMITY.

The object of restricting descent to superior individuals is to secure progeny as close as possible to the parental standard of excellence. This object is best attained when the progeny continue to follow each other in an unbroken series of individuals closely similar to the high-grade ancestor and closely alike among themselves.

Increased uniformity often constitutes an agricultural improvement of a variety quite apart from the question whether any individuals of the variety advance beyond the standard of the carefully selected ancestor of the line-bred group. It has often been supposed that progeny obtained under restriction of descent are actually superior to any of their broad-bred ancestors, but this is now seriously questioned, and many recent writers have denied it altogether. The chief advantage gained through restriction of descent is conservative rather than constructive. The practical improvement of varieties by selection and other forms of restricted descent lies in the preservation of characters that already exist rather than in the attainment of new characters.

VEGETATIVE PROPAGATION THE MOST EFFECTIVE METHOD OF LINE BREEDING.

There can be no doubt that the most effective way of securing the desired uniformity and of maintaining it for long periods of time is by the process of vegetative propagation as applied to many cultivated plants. To prove this by new experiments might require far longer than the lifetime of a man, but the history of agriculture makes such experiments unnecessary. We know that many tropical root crops and other plants have been propagated from cuttings since very remote periods, to be counted in thousands of years. Our carefully selected narrow-bred varieties of seed-propagated plants have been known for only a few decades at the most. The majority of them go out of use and disappear after only a few generations, giving place to other "new" varieties, better at first than the old, but giving no more assurance of permanent superiority.

VEGETATIVE PROPAGATION DEPENDS ON LONGEVITY.

To treat vegetative propagation as a form of line breeding may appear unwarranted in view of the current opinion that vegetative propagation is a purely nonsexual process, whereas self-fertilization and in-and-in breeding are usually viewed as forms of sexuality. It is true that vegetative propagation is often carried on by parts of plants which have no apparent connection with the organs of sexual reproduction, but there are other and more fundamental considerations which show that all of our higher types of plants are continuously dependent for their existence upon the sexual process of conjugation, without regard to whether particular individuals are raised from seed or grown from cuttings.[a]

It is misleading to suppose that vegetative propagation as carried on by the higher plants involves a cessation of conjugation. New conjugations become unnecessary because the old conjugation is greatly prolonged. Thus vegetative propagation is not to be considered as a substitute for conjugation, but as evidence of an ability of the cells of the plants to continue in a state of conjugation without the need of frequent renewal. This power to maintain existence by vegetative propagation depends upon a special property or quality not shown in plants whose cells are able to remain in a state of conjugation only for the lifetime of a single seed-propagated individual. Vegetative propagation is to be viewed as a form of longevity of the protoplasm, enabling growth to continue without a new conjugation. Without this power of longevity, vegetative propagation would be as impossible as it would be for an annual herb to grow into a tree. Species and varieties differ greatly in their powers of vegetative propagation, just as they differ in other forms of longevity.

Many writers have recognized that conjugation is a means of rejuvenation or renewal of the energy of the protoplasm. The bodily activities of organisms appear greater in young plants and animals and lessen with age. The renewal of the energy of the protoplasm by conjugation is effective in different species for very different periods of time. Many plants are annuals, living for only a few weeks or months, while others have an enormous longevity. The ages of individual trees of several different species have been reckoned in hundreds or thousands of years. To maintain the life of such organisms the process of conjugation must have a long-sustained efficiency, avoiding the need of the frequent renewal, as in vegetative propagation.

The longevity of a plant capable of vegetative propagation is not to be measured by the life of a single individual, but by the length of the series of vegetative individuals that can be produced without renewed conjugation. Differences of longevity probably represent differences in the structure or quality of the protoplasm itself. Rudely, we may compare the organisms to clocks and say that some have stronger mainsprings or are more effectively wound up. In vegetative propagation we may say that the protoplasmic mainsprings outlast the individual organisms and remain serviceable through a long series of organisms.

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[a] Cook, O. F., and Swingle, W. T. Evolution of Cellular Structures. Bulletin 81, Bureau of Plant Industry, U. S. Department of Agriculture. 1905.

Longevity is not proportional to size. The persistent vegetative growth of some of our herbaceous plants might enable them to excel the largest trees if all the tissues originating from a single seed could be kept together as in the case of the trees. The tree lives only as long as the protoplasm of the cells retains its vigor, or until it becomes too large to support or nourish itself, but with a perennial herb the longevity of the protoplasm is passed on through many vegetative generations. The individual plant may not remain alive for more than a year or two, and yet the same rootstock may creep along in the ground for decades or centuries. The greater longevity of plant organisms may depend somewhat upon the fact that they continue to form new tissues instead of attaining a definite maturity merely from the different habits of growth. The weakened vitality of the protoplasm may be the same in the vegetative variety as in a tree or a long-lived animal, the difference of visible results arising merely from the different habits of growth. The weakened vitality of old varieties of potatoes or of sugar cane may be compared with the gradual weakening of aged trees or of aged men. There is a slackening of the organic energies which can be quickened only by new conjugations.

In a species in which the individuals are short lived we think of a new conjugation as necessary to restore the energy of the protoplasm for the growth of each generation. With long-lived species or those capable of vegetative propagation it is evident that there is no such necessity of frequent renewal of conjugation.

Additional insight regarding the nature of conjugation has been gained in recent years. Instead of conjugation being a process which takes place only when a new generation is to begin, it is now known that the cells which compose the bodies of the higher plants and animals all represent a state of prolonged conjugation. They are not like the simple cells which are formed *between conjugations* in the lower and more primitive groups, but are double cells like those which are formed in the lower groups only *during conjugation.* The complex bodies of the higher plants and animals are built up, not merely because conjugation takes place, but because conjugation continues throughout the lifetime of the individual, however long this may be.

OTHER METHODS OF LINE BREEDING.

Having once recognized that the vegetative propagation of our cultivated plants is a form of longevity, it becomes easy to see that other methods of line breeding are very similar to vegetative propagation. The only difference between vegetative propagation and parthenogenesis is that in the latter the vegetative development of the new individual arises from tissues which usually serve the purpose of reproduction rather than from parts that are purely vegetative. The cells which normally produce the germ cells grow into a small embryo-like bud, so that seeds are developed without access of pollen.

Self-fertilization is not far from parthenogenesis, for it is accomplished by reuniting cells of the same plant only recently separated. In self-fertilization the appearance of normal conjugation is maintained, but the results do not correspond to those of the interbreeding of different individuals. Self-fertilized types show the same uniformity of character expression as vegetative varieties, the same failure to permanently maintain the life of the stock, and the same gradual loss of vitality with age.

In-and-in breeding is the nearest approach to self-fertilization possible in plants or animals which have the individuals of different sexes. The germ cells which unite are from the most closely related individuals.

In vegetative propagation and parthenogenesis there is no interruption of the process of conjugation, for no new germ cells are formed. In self-fertilization and in-and-in breeding germ cells are formed, but the conditions of normal sexual reproduction are avoided, for cells of the same ancestry are brought together again, instead of cells of different ancestry. Though the formalities of sexual reproduction are repeated, there is in reality no more sexuality, in the physiological sense, than in vegetative propagation, for the unions of cells represent mere renewals of old conjugations, instead of being truly normal new conjugations between partners representing different lines of descent.

Parthenogenesis is plainly intermediate between vegetative propagation and self-fertilization. Parthenogenetic and self-fertilized types can not be found, of course, in a state of complete seedlessness like some of our vegetative varieties, for seedlessness in a seed-propagated variety would mean immediate extinction. That so many vegetative varieties belonging to very diverse families have become seedless is one of many evidences that even the most successful form of line breeding does not maintain the full and normal vigor of organic types. The frequency of vegetative propagation and self-fertilization among cultivated species has tended to give a misleading idea of the general importance of these methods of reproduction.

A few species of plants, and especially certain degenerate parasites, appear to be uniformly parthenogenetic, but in the great majority of cases parthenogenesis appears as an alternative of normal fertilization, just as many species resort to self-fertilization or to in-and-in breeding when there are no opportunities of normal crossing.

The domestication of perennial plants propagated by cuttings was very much easier for primitive man than that of annual species of which seed had to be saved. Thus the earliest domestications were confined largely to perennial root crops and to trees, the annual species being relatively late acquisitions, as shown by the fact that most of them are still known in the wild state.[a]

Many of our self-fertilized domesticated types have open-fertilized wild relatives, indicating that the habit of self-fertilization was not the primitive condition of descent. The same is true of most, if not all, of the self-fertilized wild plants; either they are occasionally crossed or they have cross-fertilizing relatives. Among the seed-propagated cultivated species the tendency of selection is generally toward self-fertilization, even where no such selection has been intended.

Plants are often carried into regions where their insect friends or other natural agents of cross-fertilization are absent or where the climatic conditions are unfavorable for the transfer of pollen through the air. The varieties of wheat and other cereals developed in northern Europe show more pronounced adaptations for self-fertilization than those of the Mediterranean countries. This can be explained by the selective action of the northern climate. Unfavorable weather at the time of flowering might cause a total failure in a crop dependent upon cross-pollination and allow seed to be saved only from self-pollinated plants. In a similar way it is possible to explain the special prevalence of vegetative propagation, parthenogenesis, and self-fertilization among plants that bloom early in the spring when unfavorable weather is likely to prevent cross-pollination by insects.

RELATION OF SELF-FERTILITY TO VEGETATIVE PROPAGATION.

Darwin found that some plants yielded better progeny by self-fertilization than when the pollen came from other individuals of the same stock, and later experimenters have reported similar results in several self-fertilizing species. Some of the most notable instances are reported among the varieties of tobacco studied by Mr. A. D.

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[a] Cook, O. F. The American Origin of Agriculture. Popular Science Monthly, October, 1902. Reprinted in the Annual Report of the Smithsonian Institution for 1903, p. 481, under the title "Food Plants of Ancient America."

Shamel, of the Bureau of Plant Industry. Plants fertilized by their own pollen gave, in numerous instances, progeny much better on the average than plants fertilized by pollen from other individuals of the same stock. Individual members of the cross-fertilized series were equal to members of the self-fertilized series, but many were notably inferior as well as more diverse among themselves, which seriously detracts from the commercial value of the product.

These experiments are of special interest because it was ascertained at the same time that hybrids between two distinct strains of tobacco showed less individual diversity than when crosses were made among members of the same strain. Thus it becomes apparent that the diversity and relative inferiority of the progeny of the individual crosses is not to be ascribed to the crossing as such, but to the condition of narrow breeding which such a cross represents, as compared with the line-bred stock on the one hand and with the broad-bred crosses between strains on the other. We may think of the inferiority shown in the narrow-bred stocks as a result of insufficient diversity of descent as compared with broad-bred stocks, and at the same time we may recognize that self-fertilization serves to postpone the degeneration by combining cells as closely alike as possible.

Thus the analogies of vegetative propagation help us to understand how two cells of the closest relationship may continue reproduction to better advantage than those of slightly more distant relationship. Slight differences in the germ cells may be large enough to call forth individual diversity in the offspring and yet not large enough to give them the advantage of renewed vigor like that obtained by normal conjugation between germ cells derived from distinct lines of descent. The classing of self-fertilization with vegetative propagation is thus to be justified by the most practical reasons—that both attain the same results in producing a uniform progeny by eliminating the individual differences found among organisms produced by normal cross-fertilization.

That self-fertilization and cross-fertilization yield different results, the one of uniformity, the other of diversity, is a reason for believing that they constitute different processes of reproduction, though the nature of the difference is not yet known. The best suggestion of what this difference may be is afforded by a fact recently reported by Dr. Reginald R. Gates, of Chicago University, who has made a very detailed investigation of the processes of reproduction in a variety of evening primrose (*Oenothera rubrinervis*). The nuclei of the pollen mother cells were found to pass through a stage of contraction (synapsis) and to divide into pollen cells with the usual reduced number of chromosomes, but without giving any indication that a fusion takes place between two parallel strands of chromatin (mitapsis), the concluding act of the normal process of conjugation, described by many investigators of other plants and animals. Such a method of reproduction without a conjugation of chromatin (amitapsis) is very interesting as indicating that an apparently essential part of the process of conjugation may be omitted though all the external formalities of conjugation are preserved. Nevertheless, amitapsis may be considered a less violent departure from normal sexual processes than is parthenogenesis. Amitapsis could be reckoned as a production of sex cells by vegetative subdivision of a mother cell, parthenogenesis as the vegetative development of an undivided mother cell into a new organism.

If these observations on Oenothera should be confirmed and extended to other line-bred varieties we would have a reason for looking upon the individual diversity of cross-fertilized types as a result of the process of mitapsis, which appears to be omitted in these self-fertilized primroses.[a] And even if it were found that the behavior of the chromatin has no relation to other characteristics of the plants, we should not forget that uniformity and diversity are concrete facts in need of physiological explanation.

IN-AND-IN BREEDING.

Not a few plants are like the higher animals in having the sexes represented by separate individuals. In all such cases self-fertilization is of course an impossibility. The nearest approach to it is the mating of the most closely related individuals, sometimes called in-and-in breeding. Breeders of animals often secure better results by mating the most closely related individuals than by mating those that are a little less closely related, just as breeders of plants find the complete self-fertilization of a flower by pollen from its own stamens better than narrow crossing with pollen from other flowers of the same plant or from a closely related plant.

In some varieties breeding with close consanguinity has been applied with good results for a considerable series of generations. Other varieties have appeared to improve by in-and-in breeding, but soon show sterility or other degenerative weakness. In still other cases the reports indicate prompt and definite injury from in-and-in breeding. Relying on these individual experiences some breeders advocate in-and-in breeding as a general principle of the art, while others condemn it as a wholly mistaken policy.

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[a] "No indication of a doubling or pairing of the threads during these intermediate contraction stages could be observed, though they were carefully searched for. Moreover, in the earliest stages of the synaptic ball the thread appears to be as thin and delicate as in the reticulum, which does not favor the view that a pairing has taken place. The evidence, then, so far as it goes, is decidedly not in favor of a pairing."—*R. R. Gates, A Study of Reduction in Oenothera Rubrinervis, Botanical Gazette, vol. 46, p. 8, July, 1908.*

A part of the diversity of opinion is due, no doubt, to inherent differences in the longevity of the stocks. A part may also arise from the fact that some breeders have been dealing with poultry or other small animals which are usually allowed to run in flocks instead of being separated into individual lines of descent. While a flock might promptly decline under narrow breeding, careful in-and-in breeding of select individual lines of the same stock might preserve superior strains. Yet this same policy applied in a different species or even in a different variety of the same species might only hasten disaster, if the necessary protoplasmic longevity were lacking.

There is even less probability that a type can be permanently maintained by in-and-in breeding than by self-fertilization or by vegetative propagation, but the period of endurance is undoubtedly long enough in some species to give the method practical importance where uniformity and the special development of particular characters are more essential than to maintain the reproductive energy of the stock, the function in which the earliest decline may be expected. Thus it might be good policy to apply methods of strict self-fertilization or in-and-in breeding in localized varieties of cotton yielding special grades of fiber or in varieties of sheep producing a high-priced wool. The same systems might prove very unwise if the primary objects were to increase the total yield of cotton or to render the sheep more hardy and prolific.

SELF-FERTILIZATION SUPPLEMENTS BROAD BREEDING IN NATURAL SPECIES.

The flowers of some plants are so constructed that the pollen can readily fall upon the stigmas, while in others the parts are arranged so as to prevent self-fertilization. This fact has often been used to support the idea of a natural duality of methods of reproduction, an arbitrary difference of reproductive methods among the different species, not to be reconciled and interpreted by the same physiological principles. The failure to distinguish properly between the three different types of reproduction—broad breeding, narrow breeding, and line breeding—has kept contradictory opinions alive in the same way as in the question between cross-breeding and inbreeding.

The factor of longevity, the ability of the protoplasm to continue growth without a truly sexual reproduction, needs to be taken into account in understanding the great diversities of plants with respect to self-fertilization. Similar and nearly related types often differ widely in their ability to sustain themselves through self-fertilization, just as other groups of species and varieties differ among themselves in their powers of vegetative propagation.

If normal seeds can not be developed by self-fertilization, it is an advantage to a plant not to have its pollen fall on its own stigmas but to leave these unfertilized as long as possible, to increase the chances of arrival of the necessary foreign pollen. When good seeds can be formed by self-fertilization it becomes an advantage to the species to have its flowers so arranged that the stigmas are not left without pollen, just as it is an advantage to a plant able to propagate by vegetative growth to have also the habit of forming offsets. Whenever this power of sustained vitality exists it is obviously advantageous to the species to find ways of utilizing it. In all such cases self-fertilization is not to be thought of as a substitute for broad breeding, but rather as an equivalent of vegetative propagation.

A plant may have the power of vegetative propagation residing in the protoplasm, but may lack the habits of growth necessary to turn this power to practical use. Thus gardeners find it possible to propagate from cuttings many plants which grow in nature only from seeds. The date and various other palms produce, when young, vegetative shoots from the buds of the lower joints, but mature palms no longer produce such shoots. The buds of the trunk bring forth only clusters of flowers. It often happens that of two closely related species one will produce vegetative shoots and the other will not. Thus the Canary Island date palm produces no shoots, though it is a more hardy and vigorous species than the true date palm.

BROAD BREEDING AND LINE BREEDING IN THE SAME SPECIES.

That broad breeding and line breeding both have important uses in nature is shown by the fact that both are assisted by numerous and often highly specialized adaptive characters. These specialized characters become still more significant when we reflect that there appear to be no corresponding adaptations to favor narrow breeding.

Adaptations of plants to secure pollen from abroad and adaptations to insure the use of their own pollen at home both serve a common object in avoiding the worst alternative of narrow breeding. Indeed, the same plants often show both kinds of adaptations at once. The same species may have its flowers adapted to invite far-flying insects or pollen-carrying birds, and may have at the same time devices for excluding ants and other small visitors that can only crawl or fly for short distances and thus bring pollen only from flowers of the same plant or from adjacent plants, which are likely to be closely related.

Many of these apparently contradictory combinations of adaptive characters have been found in nature. They have been used by several writers to show that Darwin's idea of the development of adaptations through natural selection was erroneous, on the ground that it is illogical to suppose that the same plant could at the same time develop adaptations for conflicting purposes.

From the present point of view it becomes evident that there is no biological conflict, but an important physiological agreement between the functions of the two kinds of adaptations. They can be considered as alternative methods of avoiding the same catastrophe of extinction through narrow breeding. Self-fertility can not be of use to a plant without some underlying quality of protoplasmic longevity, like that shown in vegetative propagation, but when that quality exists self-fertilization may take on an importance only second to normal broad breeding. It is not necessary to suppose that self-fertilization takes the place of broad breeding or that it serves all the functions of normal sexual reproduction. A safer judgment is reached by comparing self-fertilization with vegetative propagation, since there is a large measure of agreement in the functions and limitations of the two processes.

That plants with conspicuous or highly specialized corollas are nevertheless capable of self-fertilization does not prove that the corolla is not an adaptive development to aid in cross-fertilization. The specialization of the corolla only shows in a more striking manner that cross-fertilization is of importance to the plant, notwithstanding its ability to propagate by self-fertilization. That a species produces seeds with its own pollen or that it is able to survive many generations of self-fertilization does not prove that the species has ceased to draw any advantage from crossing, even though its opportunities for crossing are relatively rare. The occasional exercise of normal sexuality may be quite as important for a self-fertilizing species as for one whose members are very long lived. Though self-fertilization is a frequent and entirely normal method of propagation for many plants, exclusive dependence upon self-fertilization is a very rare and abnormal condition, doubtless because it leads to ultimate decline and extinction, so that the types which may have adopted this system in the past have not been perpetuated.

LINE BREEDING A SYSTEM OF PROPAGATION.

In domesticated varieties, as in wild species, the chief value of self-fertilization and of other forms of line breeding lies in their use as methods of propagation rather than as true equivalents of sexual reproduction or as means of evolutionary progress. Marked improvements are as little to be expected from self-fertilization as from vegetative propagation. This does not mean that self-fertilized stocks are not worthy of the breeder's close and constant attention, for while there are not likely to be changes in the direction of greater vigor or increased fertility, tendencies in the other directions are frequently manifest. The practical importance of keeping a variety from deterioration may be quite as great as that of causing it to make an actual advance. Differences too slight to be detected in direct comparisons of individual plants of wheat may render one strain distinctly more productive than another, and may make a difference of millions of bushels in the harvest when the superior strain has been spread over the wide regions in which the crop is cultivated.

Unfortunately, this kind of selection, to increase or to maintain the vigor and fertility of a line-bred type, is often the most difficult to carry out in practice, one reason being that these same qualities are most seriously affected by external conditions. All breeders are familiar with the fact that conspicuously vigorous and fertile individuals may yield only ordinary offspring. An individual cotton plant of a Mexican variety grown at San Antonio, Tex., in 1906, produced much more cotton than any other plant in the field, but the offspring of this plant showed no superiority in the next generation.

When individual differences due to differences of conditions are greater than the inherent differences of the plants themselves, the inherent differences become very hard to detect. Even when the comparison is carried over to the progeny by using the test-row or centgener methods, the greatest caution has to be used to avoid mistakes from unrecognized differences of external conditions. The manner in which a field was plowed or fertilized in some previous year may make a notable difference between two rows or plots, may cause the wrong selection to be made, and may thus vitiate an elaborate experiment. The failure of such efforts at the selective improvement of varieties in vigor and productiveness has led some writers to deny that such improvements are possible.

Various attempts have been made to explain the supposed impossibility, some writers going so far as to claim that the characters of the separate lines of descent do not vary at all except as they are affected by differences of external conditions, and hence that all selection is superfluous after "pure lines" of descent have been separated. The fact is, however, that many of the experiments that have been supposed to warrant this conclusion have been carried on for altogether too short a time to justify any reasonable expectation that the results of the selection would become apparent amidst the confusion of fluctuating and environmental variations.

It is to be expected, of course, that attempts to secure a further increase of a particular character must sometimes fail if the limits of expression of the character have been reached or if the particular breed or line of descent has no tendency toward greater variation in that particular direction. But, on the other hand, we may expect with much confidence that a sufficiently persistent selection of vigorous and fertile individuals for propagating a variety will help to maintain these qualities at higher standards than if selection were relaxed and the stock were allowed to become diluted with lines of descent which had lost some of the varietal characteristics by degenerative mutation. Selection of this kind is safer and more likely to insure continuously favorable results when it is not too closely limited to single individuals or to single lines of descent, at least after the initial generation. Unless elaborate precautions are maintained in the testing of each of the lines of descent, a serious mistake may at any time be made by propagating from an inferior individual which has appeared better than its fellows because of some environmental advantage. With a somewhat wider selection there is less danger of discarding the best lines, while those that are inferior are gradually weeded out.

If selection could be finished, once for all, by the separation of a "pure line," any amount of care would be practically justified in making this separation, but if the superiority of a variety has not only to be made by selection, but also to be maintained in the same way, there is less object in narrowing the stock down to the individual line, particularly in the kinds of plants that must be sown or propagated for several generations to obtain enough seed for commercial planting. By the time that the single line has been broadened again to produce commercial quantities of seed, the differences may reappear, so that the type may be no more constant than if several individuals had been taken and a smaller number of generations had been raised. Indeed, our experiments with cotton have shown that uniformity is to be expected with more confidence from a type represented by several closely similar plants than from the progeny of a single individual plant, which is often notably diverse. Thus it may happen, where strict line breeding is impracticable, that a choice must be made between methods that most nearly approach the desired condition.

If selection could compel actual improvements of a stock, vegetative and self-fertilized varieties could be advanced more effectively than any others, for selection can be applied with greater exactness and persistence than in cross-fertilized types. And yet it is in the former classes of varieties that the limitations of selection have been most definitely appreciated.

Even among vegetative individuals of the same stock slight differences are still to be detected, and sometimes quite pronounced changes or "bud mutations" are found. There is no reason to suppose that bud mutations differ in any essential respect from mutations that arise in seedlings of narrow-bred or line-bred varieties. Nor do they need to be thought of as being less sexual than the variations of seedlings, now that we know that the sexual condition (conjugation) continues throughout the existence of the plant even when this existence is prolonged by vegetative propagation. The only distinction that can be made with certainty is that bud mutations are generally much less frequent than seedling variations, there being, apparently, a greater facility of change of characters soon after conjugation begins. Breeders of potatoes believe, according to Dr. E. M. East, that bud mutations are much more frequent in new varieties recently derived from seedlings than in the same varieties after they have been grown for a long series of generations.[c]

Whether the range of diversity in bud mutations is as wide as among seedling variations is not easy to determine, because the bud mutations are too rare to permit them to be studied in large numbers like seedling variations. Hundreds of seedling mutations of coffee have been observed by the writer in Central America, but only one bud mutation. And yet this showed its divergent characters in a manner quite as pronounced as any of the seedling variations.

The relative infrequency of bud mutations may also be responsible for the fact that they have had little practical importance. Breeders naturally feel that they have much better opportunity of selection among the rich diversities that can be called forth by returning to sexual reproduction. Certain it is that very few valuable new types appear to have been derived from bud mutations—nothing to compare to the superior seedlings of apples, potatoes, sugar canes, strawberries, and many other species. Seldom, if ever, have bud mutations been found stronger or better than the parent stock, except from the standpoint of the florist or fancier interested in multiplying slight differences of form or color.

We use vegetative propagation to preserve the varieties, but resort to sexual reproduction when we wish to improve them, especially in the direction of vigor and fertility. The same vegetative variety may deteriorate faster under some conditions than under others, or it may even regain some of its vigor when conditions are improved. It has been found in Java that sugar canes brought down from elevated localities are more resistant to disease than other representatives of the same vegetative variety which have been grown continuously at low elevations. The change of conditions gives something of the same beneficial effects that are obtained by new conjugations. New seedling varieties of cane have also been found resistant to diseases in the same way as these mountain-grown vegetative strains.

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[a] East, E. M. A Study of the Factors Influencing the Improvement of the Potato. Bulletin No. 127, University of Illinois, Agricultural Experiment Station, August, 1908.

HOW SELECTION IMPROVES LINE-BRED VARIETIES.

The fact that selection increases the agricultural value of line-bred varieties can be understood without supposing that the plants are changed in any way by the selection. The effect of selection is not biological, but purely mathematical. Selection does not give us any new characters, and does not even raise the vigor or fertility of the plants. It simply gives us the full agricultural use of the particular lines of descent that are showing the vigor, fertility, or other desirable qualities in the highest degree.

A notable improvement of a variety appears to have been made when the best individual strain has been found and the remainder of the variety has been discarded, but this is no warrant for holding that the superior strain is better than it was before. Selection then maintains the superiority of the strain by keeping it from dilution with the lines of descent in which degeneration appears, but still there is no reason to suppose that selection changes the strain.

Though continued selection may add nothing new in the way of an increase of the desirable qualities of the variety, the same reasons for continuing the selection of the variety will always remain that existed before the first selection was made, to eliminate the undesirable diversities which continue to appear even in self-fertilized and vegetative varieties. Careful selection among individuals of such varieties may always be expected to show good results. In old and weak varieties the results will be even more striking than in the stronger and more vigorous stocks, for the greater the tendency to degeneration the greater the contrast will be between the degenerate lines of descent and those that still retain the characters which give the variety its special value.

SELECTION A CONSERVATIVE PROCESS.

Favorable results from individual selections in a narrow-bred or line-bred variety is no proof that the variety as a whole is advancing in excellence, but may indicate quite the contrary—that its vigor is declining. The more rapid the decline the larger is the proportion of degenerate individuals and the greater the practical improvement worked by selection. The greater need of selection in degenerating varieties is like the requirement of more efficient police in degenerate human communities. The removal of the criminals is a practical necessity, though it does not make the community better, except in the relative sense that it may lessen the amount of crime actually committed. In the same way it is necessary to maintain a careful supervision of close-bred varieties to keep them near the standard of efficiency by eliminating the degenerate lines of descent as soon as they fall below the standard.

To compare the best lines of descent with those that have degenerated or with an unselected group containing degenerate lines shows the agricultural value of the selection, but it does not show that the best lines have been made better than they were. Domesticated varieties can be improved agriculturally without being changed biologically. There is no reason to suppose that the sorting out of the degenerate lines of descent in a strictly line-bred variety has any effect upon the lines that are retained. The practical advantage of maintaining selection can be understood without any need of supposing that the best lines are becoming better than they were. If a tendency to degeneration, such as seedlessness, paler color, or softer texture, renders a variety more desirable, the lines which are degenerate, in the biological sense, will be preferred to the others and the variety will appear to be the more improved agriculturally the faster it degenerates. It may be going too far to say that all the instances where persistent selection has resulted in continued improvement in economic characters are examples of biological degeneration, but it is certain that a very large majority are of this nature.

We need to recognize that there are two separate branches of the art of breeding, constructive breeding and conservative breeding, having different objects and requiring different methods. The former attempts to improve the characters of plants and animals; the latter, to preserve and make full use of desirable characters already obtained.

Some would restrict the word breeding to the constructive idea of improvement, which comports with the suggestion that all the processes of line breeding are to be considered as methods of propagation rather than as normal breeding in the sense of sexual reproduction. Nevertheless, such a limited use of the word breeding would exclude a large part of what is now reckoned as breeding, if not, indeed, the whole of the practical part of the subject. Breeders are often very successful in finding new characters not noticed before, as well as in making new combinations of desirable characters and in suppressing undesirable characters, but there is relatively little to support the popular idea that the operations of breeding result in "new creations," in the sense of bringing new characters into existence outside of those already attained in the course of normal evolution of species.

Whatever the differences of opinion regarding the function of selection in constructive breeding, its fundamental importance in conservative breeding will not be disputed. The superiority of the various forms of line breeding over narrow breeding is based on the simple fact that they preserve desirable characters more effectively and for longer periods of time than does narrow breeding. Line breeding is superior to narrow breeding because it is a more efficient method of selection.

The beneficial effects of selection are greatest in self-fertilized varieties because such varieties are no longer in a condition in which they can be injured by selection. A broad-bred variety may be injured or extinguished by selection, because strict and persistent selection puts an end to broad breeding and substitutes narrow breeding in its place. A variety capable of self-fertilization is less injured by narrow breeding, for those lines of descent which continue to be propagated by self-fertilization also continue to escape the bad effects of narrow breeding. Thus the tendency of persistent selection will be to preserve those strains in which the habit of self-fertilization is most strongly developed. When a condition of complete self-fertilization can be reached, as in wheat and barley, there is no longer any question of injury from narrow breeding, since all the lines of descent are propagated by line breeding.

Selection between lines of descent which are already completely separated by self-fertilization makes no further alteration in their conditions or methods of reproduction. Selection then has only the one effect of preserving the lines which express in the most uniform manner the characters most desired. If we take the trouble to choose the best strain we are assured of the best results. In no other way could this assurance be gained, for by any less stringent method of selection there is always the danger that representatives of poor or mediocre stocks are included and that the full possibilities of selection are not attained.

But no matter how effective the methods of line breeding may be in varieties adapted to these forms of propagation, their general indiscriminate application to all kinds of plants is not to be advised, notwithstanding that this course is very frequently advocated, as a consequence of the evolutionary doctrines of Professor De Vries. Rejecting Darwin's doctrine of the evolution of species through gradual changes of characters, De Vries holds that species originate by sudden changes or mutations, like those which appear in our uniform domesticated varieties. Ordinary species and varieties are supposed to consist of mixtures of large numbers of these so-called "elementary species," or "biotypes," originated by mutation. When one of these mutative strains has been separated by selection it is supposed to remain constant and uniform, except as further mutations of individuals may give rise to additional "species."

This doctrine has had in many instances the very beneficial effect of directing the attention of breeders to the advantage of line breeding, but it brings us into conflict with practical facts when it leads us to assume that line breeding is applicable to all kinds of organisms, and also when it teaches that no further selection is necessary after a "pure line" has been separated. No better illustration of pertinent facts could be found than the Triumph variety of cotton, originated by Mr. Alexander Mebane, of Lockhart, Tex., and carefully selected by him for many years. Mr. Mebane's fields of Triumph cotton at Lockhart show wonderful uniformity, as all cotton specialists have agreed who have seen them. And yet when the Triumph cotton is taken to other places, even at no very great distance from Lockhart, many notable deviations from the Triumph characteristics make their appearance. This occurs even in the first generation of plants grown from seed raised at Lockhart, before there is any opportunity for crossing with other varieties or for mutations to take place as the result of conjugation subsequent to the transfer. The Triumph embryos in the seeds or the young plants after they have germinated are able to change their characters and depart from the Triumph type. These departures, moreover, are commonly inherited by all the progeny of the variant individuals. The persistence of such variations soon puts an end to the uniformity of a variety unless a vigilant selection be maintained.

UNIFORMITY NOT A NORMAL CONDITION OF HEREDITY.

That the effects of selection upon self-fertilized varieties are always agriculturally beneficial makes it possible to understand the growth of the idea that uniformity is a fundamental principle of heredity and the first ideal of the breeder's art. Uniformity has come to be considered as an object in itself, for the very practical reason that selection for uniformity tends to carry self-fertilized varieties over from narrow breeding to line breeding even when the breeder has had no intention to make such a change of method. To adopt as a fixed ideal of selection the characteristics of the best individual member of the variety generally amounts in practice to the saving of the progeny and nearest relatives of the superior individual. The more strict the adherence to the ideal, the greater the approximation to line breeding and the better the results.

Nevertheless, it must be admitted that the value of uniformity as a method of breeding one class of varieties does not establish it as a general principle of heredity, to be applied to all varieties alike. Nor does the behavior of self-fertilized domesticated varieties show that uniformity is the natural condition of species in nature. Closer examination of the facts enables us to see why uniformity is desirable in agricultural varieties, and also why selection for uniformity tends to produce the desired result. We do not find that the idea of uniformity applies to wild species nor in the human family, nor even in the dogs and other domestic species which we learn to know as individuals. Nor have we any assurance that uniformity is a safe general guide in the field of agricultural breeding. Even in dealing with line-bred types we are no longer satisfied with likeness between individuals, but have learned to separate them into lines of descent and to judge of the value of a line of descent by the general quality of successive generations of progeny instead of from single individuals. In broad-bred types uniformity is obviously not the ideal, except to the extent that it may be necessary for commercial and industrial purposes.

TWO FORMS OF MASS SELECTION.

Writers on evolution have drawn distinctions between several different forms or conditions of selection. The selection which goes on in nature, without human interference, Darwin called "natural selection." Of selection by man Darwin distinguished two forms, unconscious selection and methodical selection. Selection becomes conscious when it has for its object the improvement of the stock. The selections carried on by primitive peoples are usually quite as unconscious as those made by birds, insects, or inanimate conditions of the environment. Thus, the Indians of eastern Guatemala have a very early, quick-maturing type of cotton, the development of which has been assisted, no doubt, by the fact that they begin to gather the cotton as soon as the bolls begin to open. This has insured the saving of seed from the earliest plants, not because of any idea of improving the crop in earliness, but because the dry season of that part of the country is short and uncertain. If the rains come too early, only the first pickings are saved; late-maturing plants are completely excluded from the stock.

The practical difference between this unconscious selection for earliness and the conscious selection practiced in more intelligent communities lies only in the keeping of the earliest pickings separate from the others. Among the Indians all the pickings are likely to be mixed together in favorable seasons, so that a definite selection takes place only in unfavorable years.

Later writers go beyond Darwin and divide methodical selection again into two forms, commonly called "mass selection" and "individual selection." This is because the progeny of single individuals kept by themselves often maintain higher averages than the progeny of several superior individuals of the same strain when allowed to interbreed. From such facts the inference has been drawn that mass selection is essentially inferior to individual selection and should everywhere be abandoned. Some writers even go so far as to deny that any improvement can be wrought by mass selection, while others object that it is slow and inefficient. Nevertheless, practical breeders are loath to abandon as worthless the method by which all the earlier improvements of our seed-propagated plants were made—the improvements which have carried them so far beyond their wild relatives in the special qualities and which render them useful to mankind.

In reality, two essentially different conditions are being confused under the name mass selection, the conditions which have been distinguished as broad breeding and narrow breeding. When mass selection is applied to a carefully selected variety or strain, derived, perhaps, from a single ancestor, the condition is the same as that here described as narrow breeding. When mass selection is applied to larger groups with more normally diverse ancestry, we have a condition of consciously directed broad breeding, a form of mass selection which may be highly beneficial.

The objections commonly urged against mass selection apply to the former condition, but not to the latter. Mass selection in a self-fertilized plant like wheat is inferior to individual selection, or line breeding, simply because it is less thorough, as already explained in previous chapters. Mass selection gives us a collection of the better of the individual strains, which must always be found inferior to the best of the strains whenever it is practicable to separate these from the others. In cross-fertilized plants and animals mass selection may be inferior for the further reason that the narrow individual crosses arouse undesirable degenerative variation.

In its application to self-fertilized plants a persistent individual selection constitutes line breeding. Nevertheless, it is dangerous to prescribe individual selection as a solution for all the problems of breeding, for it solves problems of only one kind and gives wrong indications in the others. The theory of individual selection neglects the practical distinctions between the different forms of line breeding as well as the differences between narrow breeding and broad breeding. The expression "individual selection" is in itself rather misleading, for all the methods of selection involve the selection of individuals. The difference of methods does not lie so much in the selection of individuals as in the breeding they receive after they have been selected.

THE "RUNNING OUT" OF VARIETIES.

Some horticulturists believe in the "running out" of varieties of apples, pears, and other tree fruits propagated from grafts or cuttings, while others have been unwilling to admit that varieties run out. Such differences of opinion are possible in dealing with the varieties of long-lived trees, for our varieties have not been known far beyond the span of life possible for individual trees under favorable conditions. With potatoes, strawberries, lilies, carnations, and sugar cane the weakening of old varieties is a commonly recognized fact. Specialists in potatoes and strawberries estimate the productive life of a variety between twenty and sixty years. It is the opinion of Dr. B. T. Galloway that the frequent substitution of varieties among growers of carnations is due as much or more to the greater vigor of the new seedlings than to any superior attractiveness of the flowers. The commercial life of a variety of carnations seldom lasts more than three or four years.

As vegetative varieties of many different kinds have shown the same tendency to become sterile, so it is possible that carefully selected types may reach a condition where any admixture of blood brings deterioration, as breeders sometimes claim. Improvement by crossing would then be precluded. The particular character which affords our standard of the excellence of a variety may appear for a time to increase under selection, but its highest expression is finally reached. Sterility or other forms of weakness become more and more apparent. New types arise to claim the superiority, and the old are soon abandoned and forgotten. To know that a method of breeding leads ultimately to degeneration may not remove it from the field of agricultural utility if there are compensating advantages. It may be easier to secure new varieties to replace the old ones as they decline than to apply any effective methods for avoiding the decline.

Those who are concerned to prevent the extinction of species of wild animals and plants may find an object of even greater practical interest in the danger of exterminating the wild types of our domesticated species, which future generations may find indispensable for replenishing the stock of domesticated varieties.

Though the limits can not be determined without making the experiment, we must not expect that selection or any other means can lead to an unlimited expansion of any character. Cotton plants can not be turned completely into lint, nor beets made to yield 100 per cent of sugar. Characters should not be thought of as independent entities capable of indefinite expansion; in reality, characters are only parts or functions of highly coordinated complex organisms. The existence of each character represents a cooperative result of the activities of other parts, so that the whole organism has to be unbalanced in order to permit an excessive expression of a particular part.

REJUVENESCENCE OF VARIETIES.

It is not to be assumed that all of our carefully selected varieties have reached a condition where crossing can work no improvement. For many of them it may still be of the greatest importance to provide normal fertilization at needed intervals.

The object of such crosses is not that of changing the characters of the stock, but to restore the vigor. Some breeders have reported excellent results from the rejuvenescence of varieties by crossing, but others have drawn back from such attempts because they encountered an unwelcome amount of variation. That diversity should appear as the result of crosses between varieties is of course to be expected, but it may be possible to eliminate this diversity in a few generations and yet retain an increased vigor for many generations.

In normal species, as we have seen, line breeding is not a full equivalent of sexual reproduction, but a supplementary system of propagation. Nature shows that broad breeding and line breeding may be combined, but shows also that they should not be confused or compromised into the injurious intermediate condition of narrow breeding. In domestication, too, it may often be found advantageous to combine the two methods, without confusing them. We do not insist upon growing all potatoes from seed because new seedling varieties are often superior to the older stocks which have been subjected to many years of vegetative propagation. In the same way we may find it as advantageous to resort to occasional crosses in seed-propagated plants as to adopt newer and stronger seedling varieties in species adapted to vegetative propagation.

Crossing between sufficiently remote strains of a line-bred variety may also be found highly advantageous and may help to maintain vigor, notwithstanding the fact that crosses between more nearly related lines of descent may yield results inferior to those of strict line breeding.

Even without crossing it is sometimes possible to secure a notable increase of vigor or other desirable quality through the discovery of an unusual individual. Mutations often show the same sudden increase of vigor as hybrids, and this may continue in their descendants for many generations. Many important varieties of plants and breeds of animals trace their origin and popularity to a single superior individual. Though we can hardly say that we rejuvenate an old breed when we replace it with a new one, the same agricultural purpose is attained in the two cases, especially if the agricultural qualities are the same.

A BALANCE BETWEEN BROAD BREEDING AND NARROW BREEDING.

A system which has been followed with apparent advantage in some of the carefully bred varieties of domestic animals is that of wide and continuous crossing inside the breed. Instead of limiting descent to a single individual strain or to a few related strains, the effort is made to breed together individuals which show all the characters of the breed and yet have as little consanguinity as possible. Such a system, if efficiently carried out, as among the Australian sheep breeders, keeps the lines of descent of the variety connected in a network. Though the network is narrower than in a natural species it is at the same time much broader than in ordinary narrow breeding.

Such a condition might be described as the narrowest form of broad breeding or as the broadest form of narrow breeding; it represents the boundary or balance between the two methods. It is the condition in which a considerable degree of uniformity is maintained and deterioration from narrow breeding is avoided as far as possible. For convenience of expression it seems best to consider this condition as one side of the field of broad breeding, because use is being made of crossing between different lines of descent to maintain the vigor of the stock. The practical point is to avoid the condition of still narrower breeding between this balanced condition in which the physiological effects of crossing are still utilized and the condition of definite line breeding in which narrow crossing is excluded and reliance is placed on the other principle of protoplasmic longevity.

AVOIDANCE OF UNNECESSARY UNIFORMITY.

How to maintain fertility by broader breeding and at the same time avoid an undesirable diversity of characters is one of the practical problems which each breeder must consider from the standpoint of the types with which he deals. By proper attention to the expression relations of the different characters it may be possible to secure diversity of descent with relatively little diversity of expression or to confine diversities of expression to characters which will not interfere with the utility of the breed.

In the cotton plant, for example, many characters might be allowed to vary freely without interfering in the least with the value of the product, and such variations would have positive agricultural value if they gave increased vigor and fertility. If the plants produce early crops of large bolls with lint of uniform length and fineness it makes no difference that stems have different colors or different amounts of hairs, that the leaves are differently cut, the flowers differently spotted, the nectaries and bractlets differently shaped, or the oil glands differently distributed.

This question of the amount of uniformity to be required is of primary importance in the domestication or acclimatization of new types of plants, and especially of field crops that are subject to cross-fertilization, like cotton and corn, where strict line breeding is not practicable. Not to require unnecessary uniformity in such cases does not mean that selection can be safely relaxed in types that have already been brought to a condition of uniformity, nor does it justify us in overlooking the fact that characters of no value in themselves may be worthy of careful attention when they are correlated with more important features. With cotton, for example, there seems to be a very definite correlation between the external form of the boll and the length of the lint. Plants that have longer and more pointed bolls are almost always found to have longer lint than neighboring individuals with more rounded bolls. It is therefore worth while to pay attention to the shape of the boll as well as to its size if the desirable quality of long lint is to be carefully guarded.

Similar correlations between unimportant characters and those that have definite utility have been detected by Mr. W. W. Tracy, sr., in varieties of corn, beans, lettuce, and other plants. In the Extra Early Adams variety, corn plants with branched tassels, even though they may be as early themselves as other plants with the unbranched tassels characteristic of this variety, have been found to yield offspring with a distinct tendency to later maturity. Plants of the Golden Wax beans with flowers slightly larger than normal were found to yield offspring with a distinct tendency to produce ordinary green pods instead of yellow. Certain varieties of lettuce which differ in the characters of the cotyledons have also been found to differ in the time of running to seed, even when they appear to be indistinguishably alike in the interval between.

The corn plant has been the object of much selection, but this has been directed almost exclusively to the characters of the fruit instead of to the plant as a whole. The result is that even in varieties that give relatively uniform ears and kernels the vegetative characters continue to show wide ranges of diversity in form, color, and hairiness, as well as in the tassels and flowers.

In a broad-bred stock it is evidently possible for many such features to continue their natural diversities without detriment. It is only in narrow-bred types that absolute uniformity has appeared a desirability of breeding, and this we can now understand, because the application of such standards has always tended to carry these types toward the superior condition of line breeding. The efforts that have been made to place cross-fertilized types, like Indian corn, on the same basis of uniformity as a line-bred type, like wheat, have not had any corresponding measures of success. In spite of long and persistent selection only a small proportion of the plants show any complete uniformity of the fruiting characters. The facts with reference to corn have been summarized by Mr. A. D. Shamel of this Department.

> It is the experience of most corn breeders that it is not possible to produce on an acre more than 5 bushels of uniform ears even of our most improved strains. A large majority of the plants produce ears of small size, irregular

shape, and light weight, which are undesirable. Many of the stalks are barren. Only a small proportion of the plants produce the maximum size and weight of ear.[a]

Such facts make it evident that there is a very practical distinction between the cross-bred and the self-fertilized types with reference to uniformity. Selection toward uniformity increases the yield of self-fertilized types, because their methods of reproduction are well adapted to give regularity in the expression of the desired characters, whereas the cross-fertilized types have not the same power of producing uniform offspring. With the cross-fertilized plant there is no such direct and necessary connection between uniformity in high yield and uniformity in other characteristics. If corn could be propagated by self-fertilization it might be expected to respond to selection in the same way as the self-fertilized cereals, but no self-fertilized strains of corn have been developed. In the great majority of corn varieties self-fertilization is definitely prevented by the habit of proterandry, the ripening of the pollen of the plant before its silks are ready for fertilization. In an experiment with many varieties at Lanham, Md., in the season of 1908, a single variety proved to be an exception to this rule. The stalks produced silks and pollen at the same time, but the variety can hardly be said to be in a normal physiological condition, for the leaves of all the plants were thickly spotted with yellow, a symptom not shown in any other variety.

Several experimenters have reported distinctly unfavorable results from self-fertilization in corn, the self-fertilized progeny being notably inferior to the cross-fertilized. It is possible that strains of corn may be found which will thrive under self-fertilization, but this is rendered somewhat less likely by the fact that the stamens and pistils are produced on different parts of the plant, instead of close together.

The internodes of the higher plants have, as botanists know, a certain individuality of their own, the plant being a complex or colony of many of these internode individuals. If we consider the plants from this standpoint of the individuality of the internodes it becomes plain that the pistil and stamen internodes are very close relatives in the self-fertilized cereals, while in the corn they are separated by many generations of internodes, so that their relationship is relatively remote. The self-fertilization of a corn plant does not mean the uniting of cells from adjacent internodes, as on the wheat plant, but unites cells which are in some senses as little related to each other as though they were on different plants.

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[a] Shamel, A. D. The Art of Seed Selection and Breeding. Yearbook of the Department of Agriculture for 1907, p. 227.

Thus it appears that the specialized habit of corn to produce its pistils and stamens on different parts of the plant puts it out of the reach of the kind of self-fertilization practiced in wheat. In order to make corn experiments which shall be truly parallel with those of the self-fertilized cereals, it will be necessary to find varieties with hermaphrodite flowers, indications of which are sometimes found on abnormal suckers of our ordinary varieties.

In view of these unusual obstacles to line breeding it is fortunate that corn has relatively little practical need of the uniformity which is of so much importance in crops like cotton and tobacco. The chief object in a corn crop is a large yield. A large proportion of the corn is not sold at all, but is used on the farms where it is raised. Farmers would be very willing to permit variations, even in the shapes and colors of the grains, if they could get enough more corn per acre.

Experiments have shown that increased yields can be obtained by crossing varieties of corn. Indeed, the fact seems to have been utilized since prehistoric times among the Indians of the Quezaltenango region of western Guatemala. They follow the practice of planting three different types together for the bulk of their crop, in the belief that larger yields are obtained in this way than when the varieties are planted separately. Nevertheless, breeders remain loath to advise mixed plantings of corn, or even to investigate such a possibility of increasing the yield, perhaps because this advice is so far out of accord with the methods by which some other cereal crops have been improved.

THE "FIXING OF CHARACTERS" BY LINE BREEDING.

Recognition of the superiority of line breeding over narrow breeding may help to explain the belief of many breeders that inbreeding "fixes" characters. Characters may appear to be fixed because line breeding protects a selected stock from the degenerative diversity which comes with narrow breeding. When such a line-bred stock is crossed with a narrow-bred variety there may be a definite tendency for the peculiarities of the superior stock to predominate in the offspring.

The mutations of narrow-bred and self-fertilized plants show that mere repetition does not insure stability, but may be followed by wide diversity, even after uniformity has been maintained for many generations. Selection has been supposed to eliminate undesirable characters, but in reality it is only able to postpone changes of expression relations. The characters which the breeder would eliminate continue to be transmitted and may continue to reappear, even in the face of persistent inbreeding.

RECURRENCE OF DIVERSITY IN CROSSES BETWEEN LINE-BRED GROUPS.

Further evidence that self-fertilization and in-and-in breeding are to be associated with vegetative propagation rather than with normal conjugation is found in the fact that diversity of expression reappears when diversity of descent is permitted to members of line-bred varieties.

Normal broad breeding is accompanied by alternative expressions of characters involving continual readjustments of the internal relations which govern expression. Line breeding, on the other hand. avoids such readjustments. With respect to the expression of its characters a whole line-bred variety corresponds to a single individual of a broad-bred group. Differences between line-bred varieties correspond to differences between the individual members of species, not to differences between the species themselves. All the forms of line breeding yield a relatively great uniformity of characters, but there are suggestive differences in the readiness with which the latent diversity reappears.

The uniformity secured by vegetative propagation conceals but does not diminish the inherent diversity of expression relations. The individual diversity of seedlings of vegetative varieties is familiar to all propagators of such plants. Self-fertilized types may also show a ready recurrence of diversity of characters when sufficient diversity of descent is supplied to correspond to that of normal interbreeding among the diverse members of a species. In strictly self-fertilized types, like wheat, crossing between different individuals of the same variety may bring out diversities as wide as those shown by crosses between different varieties.

In plants having a normal aptitude for self-fertilization the uniformity of varieties is to be thought of as due to this fact of self-fertilization rather than to selection alone. In a strictly self-fertilized type, selection can have reference only to the efficiency with which the characters are maintained under self-fertilization. It appears to have no effect at all upon what may happen when crosses are made, even between individuals of the same variety. The adjustment which suffices for uniformity under self-fertilization would not be sufficient to maintain uniformity under in-and-in breeding.

The effect of persistent selection is to conserve those lines of descent which have great uniformity of expressing relations along desired lines, for the others are rejected whenever their expression deviates in any appreciable manner from the standard set by the breeder. Hence the desirability of definitely directing our selection toward uniformity of expression, as in the centgener method, which tests the different lines of descent with reference to the quality of uniform excellence of the progeny rather than with reference to exceptional attainment on the part of particular individuals among the progeny.

In types not definitely restricted to self-fertilization selection for uniformity has a more definite influence upon the results of conjugation. With such types diversity comes less readily to the surface, even with crossing, but is still able to show itself in striking forms of mutative variation. Hybrids between two related varieties of Upland cotton commonly show a much smaller range of diversity than the mutations which appear in the pure-bred parental stocks. The diversity between varieties is not great enough to overcome the effects of selection and arouse the latent diversities which appear in the mutations, but when wider crosses are made between unrelated stocks the hybrids offer a wide range of diversities, corresponding to the diversities among the mutations.

CONCLUSIONS.

Long-standing differences of opinion among breeders regarding the values of crossing and inbreeding can be reconciled by recognizing the fact that there are three primary conditions or methods of reproduction, instead of two. The three conditions may be called broad breeding, narrow breeding, and line breeding.

In broad breeding there is no restriction of descent to particular lines. Unions are freely made among large numbers of lines of descent, as in natural species, where lines of descent are united into broad, continuous networks. In narrow breeding descent is restricted to unions among only a few lines, forming a narrow network of descent. In line breeding descent is restricted to simple lines, so that no network of descent is formed.

Line breeding is superior to narrow breeding, but can not be considered superior to broad breeding except for special purposes of commercial production requiring a high degree of uniformity. Broad breeding is the condition of normal evolution of species; narrow breeding the condition in which degeneration most promptly takes place; and line breeding the more stable and uniform condition desired in many domesticated animals and plants. Broad breeding is constructive, narrow breeding destructive, and line breeding conservative.

The uniformity of a group is increased by restricting descent so that all the individuals are produced from few ancestors instead of from many. Descent from many diverse ancestors maintains the individual diversity of natural species. Diversity lessens as descent is restricted, but there is also a gradual decline in the vigor and fertility of the stock. The practical importance of uniformity should not cause us to overlook the fact that uniformity must be attained at the price of deterioration. We must either avoid the deterioration of varieties or replace them frequently with new varieties.

Though all forms of restricted descent lead ultimately to degeneration, the decline may be exceedingly slow and gradual if methods of line breeding are followed. Line breeding has practical superiority over narrow breeding when it preserves desirable strains of plants or animals for longer periods of time. The ability of some species and varieties to maintain themselves under line breeding is to be considered as a form of longevity, depending on the power of the protoplasm to continue its activity without new conjugations between germ cells from different lines of descent. Species and varieties differ in their ability to persist under restricted descent, just as they differ in the longevity of the individual organisms.

Four forms of line breeding may be distinguished: Vegetative propagation, parthenogenesis, self-fertilization, and in-and-in breeding. All stages and gradations can be found, from the broad breeding of natural species, through the narrow breeding of ordinary domesticated varieties, to the strict line breeding of individual strains. The superiority of broad breeding over narrow breeding depends on the factor of normal conjugation between cells derived from different lines of descent, whereas conjugations between cells of too closely related lines often produce weak or abnormal offspring.

If conjugations are to take place between unlike germ cells, a considerable degree of diversity of parentage is to be maintained. If conjugations are to be limited to closely related germ cells, diversity of parentage is to be avoided. In broad breeding we imitate the methods of descent in natural sexual species. In line breeding we follow the analogy of vegetative propagation and self-fertilization. A truer idea of the value of other methods of line breeding is gained when we associate them with vegetative propagation than when we consider them as equivalents of the sexual reproduction of broad breeding. That no group of higher plants or animals relies for its reproduction upon any form of restricted descent forbids the assumption that domesticated varieties can be permanently maintained under conditions of restricted descent.

The superiority of vegetative propagation shows that complete cessation of conjugation preserves varieties better than conjugation without diversity of descent. In parthenogenesis conjugation is likewise in abeyance, the vegetative growth of a new organism taking the place of the formation of new sex cells. Self-fertilization is not far removed from parthenogenesis, for the cells that unite have only recently separated from the same parent and are able to combine without disturbing the expression relations of the parental characters.

Evidence of the superiority of line breeding over narrow breeding is also found in nature in the adaptations by which many wild species avoid narrow breeding. Such adaptations are not to be considered as opposed to broad breeding, because of the many cases where the same flower has two kinds of adaptations, some favorable to broad breeding and others to self-fertilization, but both tending to prevent narrow breeding. Thus it appears that vegetative propagation and other natural forms of line breeding are to be considered as supplementary to broad breeding rather than as substitutes for broad breeding.

The superiority of line breeding over narrow breeding depends on the factor of longevity in the protoplasm, to enable the growth of new individuals to continue without the need of frequent recourse to the physiological stimulus of conjugation. Varieties having the necessary longevity are propagated more successfully by line breeding than by narrow breeding, showing that protoplasmic longevity is able to sustain the vitality of such stocks better than the conjugations which occur under conditions of narrow breeding without adequate diversity of descent.

The superiority of line breeding over narrow breeding explains the improvement often wrought by closer selection in narrow-bred groups. Varieties may be improved by more rigid selection for uniformity if they are thus carried from the condition of narrow breeding toward the more favorable condition of line breeding. Varieties may be injured by more rigid selection when it carries them from broad breeding to narrow breeding, especially those varieties which can not be placed on a basis of line breeding for lack of the necessary longevity.

The effect of line breeding is to restrict the expression of characters to a single individual set by suppressing the original diversity of the group. Nevertheless, the suppressed characters have a persistent tendency to return to expression, especially when opportunities are afforded by crossings between different lines of descent or by changes in external conditions. There is no warrant for believing that any method of selection can establish varieties on a stable basis so as to prevent the return of diversity and render further selection unnecessary. Selection always appears to improve narrow-bred and line-bred varieties, not because it raises them to new standards but because it weeds out those lines of descent which have failed to maintain the old standards.

The fact that different physiological principles are involved in the different methods of reproduction practiced in the various kinds of plants and animals shows that no single generalization can be applied to the whole field of practical breeding. The success of line breeding in some cases does not warrant the advice that line breeding be applied to all cases, nor do particular failures with line breeding justify any general insistence that crossing must be practiced in all varieties. The practical need is to recognize the effects that the different methods of breeding are exerting upon our varieties, so that we may guard them against deterioration as long as possible and provide other varieties to replace them.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 147.

B. T. GALLOWAY, *Chief of Bureau.*

SUPPRESSED AND INTENSIFIED CHARACTERS IN COTTON HYBRIDS.

BY

O. F. COOK,

BIONOMIST, BUREAU OF PLANT INDUSTRY.

ISSUED APRIL 7, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

BUREAU OF PLANT INDUSTRY.

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BIONOMIC INVESTIGATIONS OF TROPICAL AND SUBTROPICAL PLANTS.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., February 2, 1909.

Sir: I have the honor to transmit herewith, and to recommend for publication as Bulletin No. 147 of the series of this Bureau, the accompanying manuscript, entitled "Suppressed and Intensified Characters in Cotton Hybrids," by Mr. O. F. Cook.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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B. P. I.—445.

SUPPRESSED AND INTENSIFIED CHARACTERS IN COTTON HYBRIDS.

INTRODUCTION.

Hybrids produced from two different types of cotton show a wide range of diversity, wider than that of either of the parent stocks. Some of the characteristics of the parent stocks may reappear in the hybrids without any notable change. In other respects the hybrids may be intermediate between the parents, or they may exceed both parents, or they may be more deficient than either parent. Finally, hybrids often show characters which the parental types were not known to possess.

These different kinds of characters of hybrids may be described somewhat more definitely as follows:

Parental characters, inside the normal range of variation of one of the parent groups.

Interparental characters, representing combinations of parental characters or intermediate stages between the characters of the parent groups.

Extraparental characters, not within the parental groups or between them. Of extraparental characters three kinds may be distinguished, as follows:

(1) *Suppressed characters*, representing the deficiency of a parental character or its reduction below either of the parent groups.

(2) *Intensified characters*, attaining a higher expression than in either of the parent groups.

(3) *Primitive characters*, representing the return to expression of characters of remote ancestors no longer brought into expression in the parent groups.

It is not to be supposed that distinct lines can always be drawn between these different kinds of characters, for there are all gradations of expression. Suppressed and intensified characters connect with parental characters on one side and with primitive characters on the other. We may look upon the suppression of a character as a return to an ancestral condition far back in the evolution of the species, before the character was developed. Intensification might also mean the return of a character to an earlier state when it had normally received a greater degree of expression. Thus the green color of the fuzz of the seeds of hybrid cottons, which was discussed in a previous report as a primitive character, might also be viewed as an example of intensification.[a]

Further studies of diversity in the Kekchi and Egyptian types of cotton have made it evident that green fuzz occasionally appears in both of the parental types, especially when they are grown under new and unwonted conditions. Several plants with greenish fuzz were found at Falfurrias, Tex., in 1908, in a plot of Kekchi cotton raised from seed newly imported from Guatemala. If hybrids were made from such plants the much more vivid green color of their seeds might be viewed as an intensification of the dull grayish green of the seeds of the parent rather than as a definite recall of a primitive character from a more remote ancestor. Green fuzz appears in our imported Egyptian cotton even more frequently than in the Kekchi, but also in duller shades than in the hybrids. Even when the seeds of Kekchi or Upland hybrids with the Egyptian cotton have no fuzz, a tendency to suppression or intensification of parental characters is still evident, for the seeds are often more completely naked than those of the Egyptian parent, where the ends of the seed commonly have small patches of rather sparse, short fuzz.

SUPPRESSION AND INTENSIFICATION AS PHENOMENA OF HEREDITY.

The phenomenon of suppression of characters is not confined to cotton or to hybrids, but is a general fact of heredity both in natural species and in cultivated varieties. Whenever an ancestral character reappears after a lapse of generations we know that it has continued to be transmitted through the generations in latent or suppressed form. The object of careful selection as applied to domesticated varieties of plants or animals is to suppress their undesirable characters while keeping their desirable characters regularly expressed or intensified. The suppressed characters are not destroyed or entirely eliminated by selection, but continue to be transmitted in latent form. They are likely to reappear at any time, and especially when hybridization or change of external conditions disturbs the internal adjustments that control the development of the plant and determine the expression of the characters.

The idea of intensification of characters, though less familiar than that of suppression, has equal warrant of natural analogy. Evolution itself may be considered as a process of suppressing some characters and of intensifying others; that is, of raising them to higher degrees of expression. That hybridization has these opposite effects of suppression and intensification may simply mean that it profoundly disturbs the ordinary process of expression, weakening the expression of some characters and strengthening the expression of others.

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[a] Reappearance of a Primitive Character in Cotton Hybrids. Circular 18, Bureau of Plant Industry, U. S. Department of Agriculture. 1908.

Suppression and intensification can not be understood, or even considered as possible, if we think of heredity as consisting of the single process of transmission. The facts commonly ascribed to heredity include the results of two distinct processes—transmission and expression. The same character transmitted from the same parental stock to two series of cotton hybrids was in one series entirely suppressed, while in the other series it came into expression in more intensified form. The transmission of a character is not to be judged from its visible presence or absence in any particular individual or series of individuals.

The farther science penetrates into the processes of organic reproduction the more wonderful do they appear, for as yet nothing has been found in the reproductive cells to correspond to the mechanisms required by various theories of transmission. Not only are there no indications of preformed organisms or models of organisms in the protoplasm of the reproductive cells, but all the parts and particles of cells thus far rendered visible to human sense appear to be capable of many changes without any apparent corresponding effect on the final results of heredity. Indistinguishable germ cells may reproduce very diverse organisms, or germ cells which appear to have definite differences may develop into organisms closely alike.

If organisms transmitted to their descendants only the characters that appear in their own bodies we could still continue to suppose that heredity might be explained in some simple mechanical way. But when we take into account the fact that plants and animals inherit from their parents and transmit to their descendants large numbers of peculiarities, or characters, which are not shown in their own bodies the mechanical theories of heredity appear entirely inadequate.

We take it as a matter of course that sons do not resemble the father alone, but may show the traits of the mother's family in the voice, or the beard, or other masculine traits or peculiarities. Yet all such cases are evidences of this general fact regarding heredity which is still left largely out of account, even by special students and writers on the subject—the fact that characters can be transmitted from one generation to another without being brought into expression. Thus the ordinary processes of heredity, as shown in the inheritance of sexual differences, abound in instances of alternations between the suppression and intensification of characters.

The current idea that hybrids represent mere mixtures or combinations of parental characters has also tended to interfere with a recognition of the phenomena of suppression and intensification. The behavior of these cotton hybrids does not comport with the idea that hybridizing or crossing among the members of a species has the effect of hindering or preventing evolution by smoothing down their differences into intermediate averages. Experiments with narrow-bred varieties, like those performed by Mendel, have shown that contrasted parental characters need not combine into an intermediate average, but that one may be dominant over the other and gain exclusive expression, though both characters are transmitted to later generations. These experiments with hybrids between different types of cotton afford excellent instances of another class of facts, showing that hybrid organisms may not merely preserve the features of the parents, but may go farther than either of the parents in the expression of the parental peculiarities.

SUPPRESSION OF BRACTLETS IN HYBRIDS OF UPLAND COTTON.

The most definite illustration of suppression of characters in cotton hybrids was found in a cross between the Kekchi type of cotton from Guatemala and the McCall variety of the United States Upland cotton. Two series of these hybrids were grown at Falfurrias, Tex., in the season of 1907, one a cross of McCall by Kekchi and the other the reciprocal cross, Kekchi by McCall.

No general differences of behavior could be detected between the two lots of hybrids. In size, habit of growth, and other vegetative features they showed a marked resemblance to the Kekchi parent and were all very much alike except two individuals which differed notably from the rest and had an equally definite resemblance to the McCall parent. A close examination of these individuals, to see whether any sign of the Kekchi parentage could be found, showed that they had no bractlets, though these organs are generally well developed in the Kekchi cotton and are usually to be relied upon as distinctive of Kekchi hybrids. But on taking the precaution to verify this supposed presence of bractlets in the other hybrids, where there was a marked predominance of the Kekchi characters, it was found that these also were lacking in bractlets. Every individual was examined, but not a trace of a bractlet was found.

The bractlets are small leaflike organs found inside the involucre which incloses the bud of the cotton plant. When the bractlets are well developed they have somewhat the size and general appearance of the stipules, the two small pointed organs found at the base of each of the ordinary leaves. The presence of bractlets may be considered as a primitive condition, since involucral leaves provided with stipules must be reckoned as less completely specialized than when the stipules are entirely suppressed.

Many intermediate stages have been found, showing that the three large bracts of the involucre represent as many leaves whose greatly reduced blades are united with their greatly enlarged stipules. There are also many intermediate stages between the bracts and the parts of the inner cup surrounding the bases of the petals. This cup is generally described as the calyx, but may prove to be an inner involucre. Under such an interpretation of the parts it becomes possible to reckon the bractlets as stipules of the bracts which form the inner involucre, corresponding to the 10 or 12 narrow pointed organs which subtend the 5 or 6 lobed inner involucre of the okra plant. The only difference would be that the bractlets of cotton have retained their stipular form much more nearly than those of the okra, and that they do not appear on all the bracts of the inner involucre, but only on those that bear nectaries—those that stand opposite the three openings between the external bracts.

The Kekchi and other related Central American types of cotton have the bractlets larger and more frequently present than in any other kinds thus far known. Among our United States Upland varieties the bractlets are much less frequent than in the Kekchi, but are nearly always to be found by a little persistence in searching. Only in the Old World types of cotton do the bractlets appear to be entirely lacking. Even in the McCall variety bractlets are occasionally present. The complete suppression of the bractlets in the one series of hybrids represents a condition for which no parallel has been found in either of the parent stocks.

Hybrids between the Kekchi cotton and other Upland varieties usually show notable reductions of the bractlets from the Kekchi standard of expression, especially when prolonged dry weather keeps the plants small and compact. Even among the Kekchi plants which have not been hybridized, notable differences may be found in the expression of the bractlets. In some of the selections of small, compact plants bractlets are very scarce, but in all the other hybrids and Kekchi selections bractlets have been found on a very large proportion of the luxuriant, freely branching plants which resemble the McCall-Kekchi hybrids of 1907. These hybrids remain as the only observed instance of a complete lack of bractlets in plants of luxuriant growth.

The only fact which seems to have a possible bearing on this strange occurrence is that the bractlets of the McCall and some of the similar cluster types of cotton appear to be very narrow and slender, more so than in other kinds of Upland cotton. It is possible that a specialized form of the bractlets might not combine readily with the more primitive form shown in the Kekchi parent and that this incompatibility might lead to the suppression of the bractlets even in plants that showed a preponderance of other Kekchi characters.

INTENSIFICATION OF BRACTLETS IN HYBRIDS OF EGYPTIAN COTTON.

The behavior of the bractlets in hybrids between the Kekchi cotton and the Egyptian is in marked contrast with that shown in the McCall and other Upland hybrids. Instead of the complete suppression of the bractlets or of any general tendency to reduce them below the Kekchi standard, the bractlets show an opposite tendency to exceed those of the Kekchi parent. This is the more notable in view of the fact that the expression of the bractlets among the Sea Island and Egyptian varieties is usually weaker than in the Upland varieties; sometimes there are no bractlets at all in a whole planting.

Yet when these same Sea Island and Egyptian varieties are crossed with the Kekchi the bractlets are often larger and appear with greater regularity than in the Kekchi cotton itself. Hybrid plants have been found with every involucre provided with a full complement of six well-developed bractlets, a degree of regularity which has never been observed in the Kekchi cotton. Single involucres with six bractlets are occasionally found in the Kekchi cotton, but this regularity is not usual even in single flowers, to say nothing of finding it on all the flowers of a plant. Among Upland and Egyptian cottons bractlets commonly appear alone or only two or three in an involucre; an equal pair is a very rare occurrence. The frequency of such pairs distinguishes the Kekchi from the other cottons, but these hybrids go far beyond the pure Kekchi.

Intensification, like suppression, is not equally pronounced in all cases, but is much more notable in some plantings than in others. Bractlets are generally more numerous in the plants that show Kekchi habits of growth and other Kekchi characters than in those that approach more nearly to the Egyptian parent. Nevertheless, bractlets are seldom entirely lacking in any of the hybrids between the Kekchi cotton and the Jannovitch variety of the Egyptian, on which observations have chiefly been made.

Natural conditions which tend to give the plants Kekchi habits of growth tend also to increased expression of the bractlets. The series of hybrids which showed the greatest development of bractlets were second generation plants grown at Falfurrias, Tex., in 1907, in the same field where the hybrids between the Kekchi cotton and the McCall variety of Upland cotton showed a total suppression of bractlets.

INTENSIFICATION OF OTHER CHARACTERS.

Though no other examples of suppression and intensification as striking as those of the bractlets have been found, similar tendencies occur in connection with several other characters, both vegetative and reproductive. The great size and superior vegetative vigor of many of the hybrid plants may be reckoned as phenomena of intensification, for while the largest plants commonly show more resemblance to the Egyptian parent in their habits of growth, they are often twice the size of any of the pure Egyptian plants in the same field, and from five to ten times as large as ordinary Kekchi plants. Even in dry localities where the growth of the plants appears to be checked by lack of water the hybrid plants continue to grow more vigorously than the others and attain much larger proportions.

The leaves of hybrid plants not only show many gradations between the broad lobes of the Kekchi and the narrow lobes of the Egyptian, but occasionally become even narrower than the Egyptian. Nevertheless, it may be that this is not a true instance of intensification, for there are forms of Upland cotton with still narrower lobes than the Egyptian.

The involucral bracts of the hybrids are often larger than those of either parent. Nearly all of the large bracts inherit the cordate shape from the Upland parent. The rounded lower lobes, instead of being reduced and rendered intermediate between the parental forms, are often more pronounced than in the Upland, and afford one of the most reliable marks for distinguishing Upland hybrids from the pure Egyptian plants. The margins of the bracts also afford examples of intensification of the Upland characters, for the teeth are often more numerous and better developed than in the Upland parent. In very rare cases there is a reduction of the teeth to below the Egyptian number. Intensification also appears in the nectaries of the involucre. Some of the hybrid plants have the outer nectaries larger than in either parent and present with greater regularity, for in the parent types involucres are often found in which only two of the bracts have nectaries, and sometimes only one or none at all.

An indication that intensification may also affect the bolls and the number of locks in the bolls of cotton hybrids may also be noted. Several plants notably similar to the Triumph variety of Upland, and probably hybrids of that variety, were found in a Mexican stock at Yuma, Ariz., in 1908. The bolls of these supposed hybrids, while not larger than the parent varieties often produce, were distinctly larger than those produced by either of the parent varieties at Yuma. There were also about three times as many 5-locked bolls as 4 locked, whereas the parent varieties showed at Yuma only about equal numbers of 5-locked and 4-locked bolls. Yet this does not involve an actual increase of locks beyond the range of the parent types, for under favorable conditions the percentage of 5-locked bolls in Triumph runs about as high as in these supposed hybrids.

Nevertheless, the ability of hybrids to resist the unfavorable conditions and retain the large size and many locked characteristics of the bolls is a matter of practical interest, of which other examples are to be given. That the conditions of the Yuma experiment were really unfavorable was also shown in many other varieties, not only in a general reduction of the size of the bolls and of the numbers of locks, but in the unusually rounded form of the bolls. The length of the lint was also found to be much reduced. There appears to be a very general correlation between the shape of the boll and the length of the lint running through all the varieties of cotton that have been studied with this idea in mind, plants with more rounded bolls having shorter lint.

DETERIORATION OF LINT IN UPLAND HYBRIDS.

Many crosses have been made between the Kekchi cotton and the United States Upland varieties with the object of adding some of the weevil-resisting characters of the Kekchi to the Upland stocks. The utility of these hybrids is still in doubt for the reason that the lint is notably inferior to that of the parent stocks, at least in the earlier generations. This is not a case of complete suppression like that of the bractlets, for the hybrids all have lint. Nor is the lint of the hybrids shorter than in inferior plants of the parent stocks. But if the possession of long lint were to be considered as a separate character there would appear to be a complete suppression, for all the plants of the first hybrid generation have short lint, with great regularity. In the second generation, also, the lint remains short, though not so uniformly so as in the first. In the third generation individual plants have shown marked improvements, proving that the long lint character has only been suppressed, not lost altogether. The short lint of these hybrids might also be reckoned as representing the return of a primitive character to expression, like the green color of the fuzz of the seed which appears in some of the same hybrids and often remains for only one or two generations.

IMPROVEMENT OF LINT IN EGYPTIAN HYBRIDS.

The length of lint shows the same strange divergence of behavior in Egyptian hybrids as did the bractlets, which were suppressed in the Upland hybrids of the Kekchi cotton and intensified in the Egyptian hybrids. Instead of becoming shorter than in either of the parent stocks, the lint of hybrids between Upland types of cotton and the Egyptian type is longer than in either parent. The strength of the fiber is notably improved, as well as the length.

These favorable reactions seem to be more regular and more pronounced in hybrids between the Egyptian and the Kekchi cottons than when the Egyptian is crossed with United States Upland varieties. The Kekchi hybrids also have an advantage in fertility by reason of the greater length of the lower fruiting branches and in the greater frequency of 5-locked bolls. Very few of the Egyptian-Upland hybrids have 5-locked bolls, and then only in small numbers, whereas the Kekchi hybrids commonly have good proportions of such bolls.

The intensification of the lint characters in the first generation of the Egyptian hybrids of the Kekchi cotton is quite as regular a phenomenon as the deterioration of the lint in the first generation of the Kekchi-Upland hybrids. Though not entirely uniform, of course, the lint of the hybrids has in all cases been distinctly more uniform than that of the parent stocks growing under the same conditions. Only in carefully selected varieties grown under thoroughly accustomed conditions do we find greater uniformity than the hybrid plants have shown. The lint of the hybrids is notably less affected than that of the parent stocks by the diversity which appears during the process of acclimatization. Thus it may be argued that suppression and intensification are definite facts in the heredity of these hybrids—even more definite than the ordinary processes of heredity, which permit a wider range of variation.

Nevertheless, it must not be forgotten that suppression and intensification are definite phenomena only in the first and second generations. They can not be reckoned as permanent qualities of the hybrids, but may be thought of as results of the special conflicts or stresses between divergent tendencies in the early generations of the hybrids. In later generations, when the predominance of one or the other of the parental types becomes more definitely established in the hybrids there is a notable decline in length and strength of the lint. There seems to be a general tendency for the Upland characters to gain the ascendency in the later generations. The lint also shows a notable approximation to that of the Upland type, but commonly falls to the condition of very inferior Upland, as though all the effects of selective improvement of the parent stocks had been lost.

POSSIBILITY OF UTILIZING INTENSIFIED HYBRIDS.

That crosses between Sea Island or Egyptian cotton and varieties of the Upland series often produce lint of very high quality has been known, of course, to all who have made experiments with this group of plants. But whenever attempts were made to utilize this superiority in developing superior hybrid types of cotton the way has been blocked by the facts already stated, that the condition of intensification is not permanent but gives way to diversity and deterioration in the later generations. The tendency to reversion and deterioration is persistent and appears not to yield to the most rigid selection. Individual plants with superior lint continue to appear, but the average rapidly declines far below that of the Egyptian parent, if not below the Upland. The lint of the degenerate hybrids of the later generations is not only short, but is often as remarkable for weakness as that of the early generations is for strength.

The transient character of the phenomenon of intensification shows that it can be utilized only in the first generation of the hybrids, or at most in the first and second generations. To make this possible large quantities of first generation hybrids must be obtained, and by methods less difficult and expensive than hand pollination. In order to be of commercial value whole fields of hybrids would have to be grown. Hybrids are easily obtained by planting Uplands and Egyptians close together and allowing the bees to cross-fertilize the flowers. But hybrids are no advantage when mixed with the parent stocks, in spite of the superiority of their lint, for they interfere with the uniformity requisite in high-grade cotton. They would be of much greater value if kept by themselves.

The study of the hybrids between the Egyptian cotton and the Kekchi suggests a practical way in which this may be done. When the Kekchi cotton is allowed to become crossed with the Egyptian pollen the large, smooth hybrid plants growing among the small, hairy Kekchi plants are very conspicuous, so that it would be easy to pull out the Kekchi plants and leave the field stocked with hybrids alone. The use of Upland varieties for the making of such hybrids may also be practicable, but somewhat more skill may be required to distinguish the young plants in the earlier stages. By planting alternate rows of Kekchi and Egyptian in special seed plots, a large proportion of hybrid seed would be obtained, and with no greater trouble or expense than would be required to maintain an adequate selection of any superior variety of cotton by the methods now used in the production of Sea Island and other high-grade types.

RELATION OF COHERENCE OF CHARACTERS TO INTENSIFICATION.

In hybrids between different types of cotton there is a distinct and very general tendency to coordination or coherence of characters. Notwithstanding the fact that there are large numbers of contrasted differences between the parental types, the hybrids sometimes show only the characters of one parent, by a consistent suppression of all the diverging tendencies derived from the other parent. Such plants are likely to be somewhat peculiar in comparison with pure-bred individuals of the type they resemble, but without showing any definite departure beyond the range of variation of the parent type. There appears to be a rather definite gap between these hybrids that resemble one parent exclusively and those that show characteristics of both parents. No cases were found where one character of one parent was definitely expressed in a plant otherwise having an exclusive resemblance to the other parent. If an Egyptian-like plant shows one obvious Upland character other Upland characters are always found very definitely indicated, if not fully expressed.

The production of high-grade lint by the hybrids appears to be definitely related to this coherence of characters. Hybrids which resemble only one parent have also the lint character appropriate to that parent. Special excellence of lint and high fertility have been found only in plants that show their hybridity by the definite expression of characters of both parents. In addition to this general tendency for the characters of the same parent to appear together. there is a more particular tendency for corresponding or closely associated characters to preserve their coherence. Thus hybrids with pale flowers also have the flowers of the open, cuplike, Upland form instead of the more narrowly tubular form of the Egyptian flower. Incongruities, such as flowers of Upland shape with the darker Egyptian color, are rare and have been found thus far only on plants which are nearly sterile or otherwise definitely degenerate.

Though the experiments have not been carried far enough to afford conclusive evidence, it appears that the tendency of the Egyptian characters to gain exclusive expression in members of the first and second generations gives place in the later generations to an opposite tendency toward the exclusive expression of Kekchi or Upland characters. This increasing potency of the Upland characters in the later generations may be looked upon as the cause of deterioration of the lint, since it puts to an end the condition of mixed expression of characters under which the intensification appears.

INFLUENCE OF EXTERNAL CONDITIONS ON INTENSIFIED HYBRIDS.

In addition to the superiority of their lint, the vegetative vigor of the hybrids gives them a great advantage in the field. They are much more fertile than the parent types, often producing several times as many bolls as adjacent Egyptian plants. A single hybrid plant grown at Yuma in 1907 is reported by Mr. W. A. Peterson to have borne over 1,100 bolls. Plants with 200 to 300 bolls are frequent. The hybrids also appear to be much less susceptible to injury from adverse conditions, either in the yield or in the quality of the lint. Yet there are notable differences in the behavior of the hybrids in different places, and these differences will need to be taken into account if commercial cultures of hybrids are attempted.

The external conditions are able to affect the yield and the quality of the lint of the hybrids through the coherence of characters described in the previous chapter. The hybrids which resemble only the Egyptian parent in its unacclimatized form and fail to show any definite Kekchi or Upland characters or any improvement of lint have all been found under conditions favoring the development of the tall, erect form in Egyptian plants. In a planting at Coachella, Cal., in 1908, Mr. T. H. Kearney found that the hybrids resembled the pure Egyptian plants much more closely than at Yuma or at Sacaton, Ariz. Neither by the habits of growth nor by the more detailed differences, such as the form and color of the bolls, could the hybrids be recognized with the same readiness as in the Arizona plantings.

Where the external conditions favor the Egyptian habit of growth it is possible to find plants, even in the second generation of hybrids, that show only Egyptian features either in the vegetative parts of the plant or in the seeds and lint. Careful study of such a plant was made at Del Rio, Tex., without finding any of the signs of hybridity which had been very apparent in the parent of this particular plant and had been carefully noted in the preceding year. Other plants in the same row showed many degrees of expression of the Egyptian characters, and there appeared to be a very consistent relation between fertility and superiority of lint, increasing as the non-Egyptian characters came into expression. The conditions of growth were distinctly unfavorable to fertility in Egyptian cotton and the plants appeared to be affected by them to an extent corresponding to the degree of expression of the Egyptian characters. In an adjoining row of Egyptian plants a few individuals that were distinctly more fertile and had better lint than the others also gave distinct evidences of hybridization.

On the other hand, when the conditions definitely favor the expression of Upland or Kekchi characters there is a notable improvement in the yield. Even the second generation of the hybrids may produce excellent, uniform lint, as was shown in the season of 1907 at Falfurrias, Tex., where the vegetative development of the plants was definitely restricted by dry weather and the Kekchi habits of growth and other Kekchi characters were called forth. And even though some of the Kekchi characters are present, the improvement of the lint may not be very pronounced when the hybrids are raised under conditions of too great humidity so that the plants become crowded together and are obliged to grow tall and spindling and bear no fruit on the lower branches. The lint averages much better on hybrid plants grown in more open situations where they are able to begin bearing while still young.

Relatively dry localities would also be more favorable for the production of hybrid seed, for if the Egyptian plants become too luxuriant they might not begin to blossom until after the Kekchi plants had set most of their crop, so that very few hybrids would be obtained. Dry soils which retard the vegetative growth of the Egyptian plants also incline them to earlier flowering. To secure a maximum of cross-fertilization it might be necessary to plant the Egyptian cotton in advance of the Kekchi.

Breeders and students of heredity will understand from these facts that the behavior of these hybrids between different types of cotton is quite different from what would be expected in Mendelian hybrids between narrow-bred varieties or strains of the same variety. Increased vigor and fertility are commonly found in crosses between narrow strains, the so-called "elementary species" or "biotypes" used in Mendelian experiments, but such crosses of closely related varieties of cotton do not appear to give any such definite phenomena of intensification as do hybrids between widely different types. The characters of such hybrids would be described as parental or interparental, not as extraparental.

In Mendelian hybrids the characters derived from the same parent show no such coherence of expression, but appear in all sorts of combinations with characters of the other parent. This indicates a complete freedom of substitution or alternation in the expression of Mendelian characters. Nor has it been supposed that the Mendelian expression of contrasted parental characters can be affected by differences of external conditions, which have such obvious influences upon these hybrids between the different types of cotton.

OTHER EXAMPLES OF THE INFLUENCE OF EXTERNAL CONDITIONS.

That external conditions have an influence upon the characteristics of plants and animals is a familiar fact, but influences of the sort indicated in the previous chapter are not commonly recognized or taken into account by scientific experimenters and breeders. External conditions may be said to influence expression in three ways, first by hindering or inhibiting expression, second by inducing an accommodation or readjustment of characters to correspond with the change of conditions, and third by throwing the expression of characters out of adjustment, so that they are changed without reference to better adaptation to the new condition.

Influences of the first kind are seen when lack of heat, light, water, or other conditions or substances needed by the plant keep it from reaching its proper stature or from showing its normal characteristics. The second effect of external conditions is seen in plants that regularly change their characters to adapt themselves to different conditions, as in the amphibious species of the buttercup family, which produce finely divided leaves when they grow in the water, but ordinary broad leaves when they grow on the land. The third effect of external conditions is seen when plants growing in new and unwonted conditions show a wide range of diversity, including many reversions and abnormalities. In such cases it is obvious that the new conditions have changed the expression of the characters, but it has also to be recognized that the changes are in the nature of disturbances of the normal expression of the characters rather than of new adjustments. Great diversity shows instead a lack of adjustment, each individual appearing to change in a different direction.

As might be expected, however, there are also intermediate stages between these three different effects. It is becoming apparent that the external conditions are not only able to call forth regular environmental adjustments, but are also able to induce somewhat regular changes of characters that have no direct connection with environmental needs.

Many plantings of Central American varieties of cotton in Texas have been rendered completely sterile through the exclusive development of vegetative branches from the axillary buds instead of fruiting branches, which arise from extra-axillary buds. This behavior may be viewed as an intensification of the vegetative tendency, which remains largely in abeyance when the plants develop in a normal manner, as they are able to do after a few seasons of acclimatization, that is, if the first plantings do not carry the vegetative intensification to the point of complete sterility.

A conspicuous example of a less violent form of intensification was observed at Del Rio, Tex., in 1907. The Parker variety of cotton showed a pronounced semicluster habit or shortening of the internodes of the fruit branches, a notable departure from the previous behavior of our stock of this variety, which had been under observation in several different localities in the preceding years. Apart from the fact that every precaution is taken to avoid mistakes in labeling and planting the seed, the possibility of error in this case seems to be entirely eliminated by the fact that six different selections of Parker were grown at Del Rio and that all of them behaved in the same manner with reference to this change in the lengths of the fruiting branches. Plantings of the same strains from the same lots of seeds in several other localities in Texas in the same season produced no such results. In other places the cluster tendency was shown in only a few individual plants. We have therefore to admit that the conditions under which the plants developed at Del Rio brought about in some unknown manner a pronounced strengthening of the cluster tendency, which affected all the plantings in a notable manner. There seems to be no escape from the recognition of the fact that there are environmental intensifications of characters quite as pronounced in particular cases as those secured by hybridization, and more stable in their subsequent expression.

The indication that the conditions at Del Rio were responsible for the more pronounced cluster tendency of the Parker cotton was confirmed by the behavior of other varieties. Those that have the cluster tendency as a usual characteristic showed it in a pronounced manner. Many other long-limbed varieties showed individual plants more or less clustered, though no other long-limbed type changed to the cluster form with any such regularity as the Parker.

In the season of 1908 conditions at Del Rio did not show any general tendency to intensify the cluster habit more than at other places. A row of Parker cotton planted for the first time at Del Rio did not become clustered like that grown in 1907, only a single plant giving an indication of a tendency to shorten the internodes of the fruiting branches. In the rows raised from the Del Rio seed of the previous year there were also many plants that had fruiting branches of the normal length and showed no sign of semicluster parentage. But in a large proportion of the plants the cluster tendency was still obvious, though it was not expressed with any such regularity as in the preceding year, but in all stages, some less pronounced than before, some much more pronounced.

In a similar manner the Del Rio seed, when taken to other places and grown in comparison with other Parker stocks, gave obvious indications of a strengthened tendency to the cluster habit, though the clustering was expressed in different degrees in different places, evidently depending somewhat upon the luxuriance of the plants. The plants of 1907 at Del Rio which showed the cluster tendency with the greatest regularity were less than half the size of those of 1908, which may be considered as abnormally large, since they were inferior in yield and quality of lint. Nevertheless, it is not to be assumed that the cluster tendency is connected with mere reduction in size, for the plants of 1907 were well nourished and very fertile. Much smaller plants can be grown under unfavorable conditions without changing the proportions of the fruiting branches. The cluster characteristic is to be viewed rather as an intensification of fertility, since in its extreme forms of expression it changes vegetative buds over into fruit buds and thus prevents the development of the fertile branches. The effect is to transform a broad, branching, tree-shaped plant into a tall, spikelike, "limbless" plant. My attention has been called by Prof. Edward L. Greene to indications of a similar transformation in a related plant, the common hollyhock, which several early European botanists figured as a branching plant of the same general form as cotton.

The same relation of the expression of the cluster tendency to external conditions has also been shown by a Mexican cotton. At Del Rio in 1907 two notably different forms of plants were found in the same row, one form characterized by shortened internodes, though also differing in other habits of growth as well as in the bolls, lint, and seeds. When the same stock was inspected afterwards at Victoria, no indication of the cluster habit could be found in any of the plants, but a careful examination of the lint and the seeds showed that both of the types which were so obviously different at Del Rio were really present at Victoria, and still distinguishable, though the fact would certainly not have been suspected without the previous attention to the more conspicuous differences which came into expression at Del Rio.

The behavior of the Del Rio semicluster selection of this Mexican stock in 1908 showed a very definite inheritance of the cluster tendency. At Del Rio, where the conditions were not so favorable for the expression of this characteristic as in the year before, it was still very apparent, and in other places it came into still stronger expression than at Del Rio. At Yuma there was an opportunity to compare the Del Rio semicluster selection with another selection made at Yuma from the same original Mexican stock for the same semicluster characteristic. The Del Rio selection notably excelled the Yuma selection in the expression of the cluster tendency, and also showed in many individuals a distinct exaggeration of the tendency beyond the stage shown at Del Rio in the previous year. Many branches were stopped by the production of flower buds after only three or four internodes had developed. As no such degree of clustering was noted in any of the Texas localities where this stock was grown, we may consider that the transfer to Yuma had the effect of still further intensifying the condition of expression attained at Del Rio in the previous year.

After such relations of external conditions to expression have been observed in unhybridized stocks it can no longer appear unreasonable to ascribe similar differences of expression among hybrids to external influences. Thus at Del Rio in 1908 a series of second-generation hybrids between the Kekchi cotton of Guatemala and the Triumph Upland cotton were reported by Messrs. Argyle McLachlan and John H. Kinsler as showing many plants closely like Triumph. At Victoria, on the other hand, this same stock of hybrids produced only large bushy plants of the form familiar to us in unacclimatized conditions of the Kekchi. The contrast between plants of this kind and the normal form of the Triumph is very pronounced, for the Triumph has a curiously specialized habit of shortening a few of the fruiting branches near the base of the stalk.

This block of hybrids may be contrasted with the next, representing the second generation of the same Kekchi cotton crossed with the McCall Upland variety, which has normally a pronounced cluster habit. A majority of the plants had the same form as the Triumph hybrids, but many individuals were definitely clustered like the McCall grandparent. A census of the plants was made by Mr. McLachlan, who found 53 plants of the McCall type and 250 of the Kekchi, a proportion suggestive of Mendelism. Unfortunately, no count was made of the Del Rio plot of Triumph hybrids to see whether they gave any similar proportions, but the facts afford at least a suggestion that hybrids may be found which will show Mendelian proportions under some conditions, but not under others.

CONCLUSIONS.

When the diverse characters of cotton hybrids are compared with those of the parent groups, some of the parental characters are found to be intensified while others are suppressed. The same character or quality may be weakened or even completely suppressed in one series of hybrids and yet be increased or intensified in another, as shown by the behavior of the bractlets and the lint when the Kekchi cotton is crossed with Upland on the one hand and with Egyptian on the other.

In hybrids between the Kekchi cotton and United States Upland varieties the bractlets are suppressed and the lint shortened, while in hybrids between Kekchi and Egyptian cotton the bractlets are enlarged and the lint is notably improved in length and quality. In the first generation of the Egyptian hybrids the intensification of the characters which gives superiority to the lint is so regular that it may be possible to utilize it in the commercial production of high-grade fiber.

Suppression and intensification of characters are most pronounced in the first generation and tend to disappear in later generations. This fact stands in the way of the breeding of hybrid types with permanently intensified characters, but does not interfere with the commercial production of cotton from first-generation hybrids, if hybrid seed can be obtained in sufficient quantities.

It has become apparent in experiments that large proportions of hybrid seed can be obtained by planting two types of cotton close together and allowing the bees to cross-fertilize the flowers. It also appears practicable to raise fields of hybrid plants by sowing seed of Kekchi plants cross-fertilized with Egyptian pollen. The Kekchi seedlings can be easily recognized and removed, leaving only the hybrids to mature.

Such a method of producing cotton from first-generation hybrids is brought within the range of practicability in Arizona by the unusual abundance and activity of cross-fertilizing insects and by the dry climate, which enables the growth and fertility of the plants to be definitely controlled by careful irrigation. The superior quality of the hybrid cotton and the high prices it could command in the market will also justify the use of special methods of breeding and cultivation which would not be advisable in the production of a cheaper staple.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 148.

B. T. GALLOWAY, *Chief of Bureau.*

SEEDS AND PLANTS IMPORTED

DURING THE PERIOD FROM JULY 1 TO SEPTEMBER 30, 1908:

INVENTORY No. 16; Nos. 23323 to 23744.

Issued April 10, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washingon, D. C., January 15, 1909.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 148 of the series of this Bureau, the accompanying manuscript, entitled "Seeds and Plants Imported During the Period from July 1 to September 30, 1908: Inventory No. 16; Nos. 23323 to 23744."

This manuscript has been submitted by the Agricultural Explorer in Charge of Foreign Seed and Plant Introduction with a view to publication.

Respectfully,
B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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B. P. I.—448.

SEEDS AND PLANTS IMPORTED DURING THE PERIOD FROM JULY 1 TO SEPTEMBER 30, 1908: INVENTORY NO. 16; NOS. 23323 TO 23744.

INTRODUCTORY STATEMENT.

This inventory of seeds and plants imported is the sixteenth in a series which was begun in 1898. It contains the introductions of only three months, and as the three months happened to fall at a time when our agricultural explorer Mr. Frank N. Meyer was in this country preparing for further explorations and Prof. N. E. Hansen was on his way to Central Asia or preparing there to collect the seeds of wild alfalfas on the steppes, the number of plants imported is small. It represents, therefore, only those things which have been secured by correspondence with our agents and friends in different parts of the world.

Through a correspondent in Chile, Mr. José D. Husbands, an unusual collection of seventy-two potato varieties was secured, among which are wild types from the archipelago of Chiloé and the adjoining mainland of Chile. These, it is hoped, will prove of considerable value for the breeders of this important crop. The unusual interest in the Peruvian strains of alfalfa induced us to get, through Mr. T. F. Sedgwick, of Lima, a collection of ten reputed different strains, while Mr. M. Fraile, of this Bureau, brought from near his home in Villares de la Reina, Spain, plants of a wild form of alfalfa which is of especial interest to the experts on this crop. The unusual activity of the office in the introduction of the timber bamboos of the world has brought in the rare and especially frost and drought resistant form *Dendrocalamus strictus* from India, and another, a tropical species, *Chusquea bambusaeoides*, which is said to seed regularly, from Rio de Janeiro, Brazil. Mr. W. S. Lyon, of Manila, has sent a remarkable ornamental squash that looks promising for greenhouse culture; Mrs. L. E. M. Kelly has sent five varieties of the Chinese leitchee from the island of Hainan, the home of this new fruit, and through the kindness of Dr. John M. Swan, of Canton, a Wardian-case shipment of grafted leitchees was sent from Canton to the Hawaiian Islands. The seeds of a number of named varieties of Japanese chrysanthemums will interest the crysanthemum growers; the seed of a honey-scented collarette dahlia will attract the growers of this flower; the introduction of *Viola calcarata* may lead to an improvement in the ordinary pansy, and plants of *Rosa moyesi*, a distinct Chinese form, may be of value for the rose breeders. Our unusual collection of bananas has been enriched by twelve varieties from Ceylon, and a new mango of some promise from Brazil has been added to the mango collection.

It may be well to repeat what has been explained in previous inventories, that the appearance of a name and description in this bulletin does not indicate surely that the seeds or plants are available at once for the use of experimenters. The majority of this plant material has to be sent out as soon as possible after it arrives, much of it to experts at the State agricultural experiment stations who are waiting for it, and the rest to our propagating gardens, where it will be taken care of until the young plants are large enough to send out by mail to those particularly interested. An eligible list is kept and applications from private or official experimenters who feel that they are in a position to give any of the introductions a careful trial are welcomed. The more specific the application the more attention it will receive from this office, for the main object of the work is to encourage careful trials with the purpose of building up new plant industries. Whenever an experimenter thinks he sees a definite use for any one of the thousands of plants which are being imported it is the aim of the Office of Foreign Seed and Plant Introduction to put the living seeds or plants desired in his hands. As far as the limited facilities of the office permit, we will therefore agree to hunt up and get plant material of an experimental character, provided it is not listed in the seed or nursery catalogues of this country, and will place it in the hands of experimenters who can satisfy us of their ability to use it intelligently.

As it is of great importance that a historical record be kept of the success or failure of the many introductions, it is especially requested that whenever an experimenter makes a success of the plants sent him, and particularly if he publishes anything about them, he will notify the office and publish the office number, which is invariably sent out with every plant or package of seed, or, if the number is lost, he will at least give the date when the seed was sent him, so that through the accurate records which are kept the source of the seeds can be traced. It should also be remembered that a report of failure, while negative evidence, is often of very considerable value.

DAVID FAIRCHILD,
Agricultural Explorer in Charge.

OFFICE OF FOREIGN SEED AND PLANT INTRODUCTION,
Washington, D. C., January 15, 1909.

INVENTORY.

23323. PHRAGMITES VULGARIS (Lam.) Hitchcock (ARUNDO VULGARIS Lam.).

From Gothenburg, Sweden. Procured by Hon. W. Henry Robertson, American consul. Received July 6, 1908.

"These roots were procured for comparison with American-grown ·eeds in the study of the reed-lath matting industry proposed by Mr. Ivar Tidestrom." (*Fairchild.*)

23324. CARICA PAPAYA L. **Papaw.**

From Miami, Fla. Received through Mr. P. J. Wester, Subtropical Laboratory and Garden, July 6, 1908.

"A variety of papaw with cucumber-shaped fruits peculiarly well suited for packing. Grown at the Subtropical Laboratory under No. 516 from seed presented by Mr. Cephas Pinder, Upper Matecumbie Key. Pulp is rather thin, but the flavor is excellent. The flower is perfect and the variety appears worth testing and, if possibe, improving on the thickness of the pulp." (*Webster.*)

23325 to 23332.

From Canton, Kwangtung, China. Presented by Dr. W. H. Dobson. Received July 6, 1908.

The following seeds. Varietal descriptions by Mr. H. T. Nielsen.

23325 to 23327. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

23325. Black.

23326. Yellowish green.

23327. Yellowish green, smaller seeded than No. 23326.

23328. VIGNA SESQUIPEDALIS (L.) W. F. Wight.

23329 and 23330. DOLICHOS LABLAB L. **Hyacinth or Bonavist bean.**

23329. White.

23330. Red.

23331. PISUM ARVENSE L. **Field pea.**

23332. CAJAN INDICUM Spreng.

23333. ANDROPOGON SORGHUM (L.) Brot.

From northwestern Rhodesia. Presented by Mr. C. E. F. Allen, Conservator of Forests, Livingstone, Victoria Falls, northwestern Rhodesia. Received July 8, 1908.

Martwa. "The seeds are small, broadly obovate, somewhat flattened, flinty, pearly white with pale hulls, closely resembling some forms of *Ampemby* from Madagascar." (*Carleton R. Ball.*)

23334 and 23335.

From Grand Rapids, Mich. Presented by Mr. V. A. Wallin, Wallin Leather Company, through Mr. Frederic Chisolm. Received July 1 and 9, 1908.

Seeds of the following:

23334. CAESALPINIA BREVIFOLIA (Clos) Baill. **Algarobilla.**

Procured from an importing firm in the United States.

"A leguminous shrub or small tree the pods of which are extraordinarily rich in tannic acid, the content being as high as 67 to 68½ per cent. Tanning with these pods is accomplished in one-third of the time required for tanning leather from oak bark, and the pods are especially valuable as giving a bloom to the leather. They also furnish a yellow age." (*Extract from von Mueller.*)

23335. CAESALPINIA CORIARIA (Jacq.) Willd. **Cascalote.**

From the south of Mexico.

"A leguminous tree from the wet seashores of Central America. Each tree is said to produce annually 100 pounds of pods, the husks of which, commercially known as divi-divi, are regarded in India as the most powerful and quick-acting tanning material. The market price of the pods is from $40 to $65 per ton, and England imports about 4,000 tons annually. In India lac is also gathered from this tree." (*Extract from von Mueller.*)

23336 to 23339.

From Shanghai, Kiangsu, China. Presented by Dr. S. P. Barchet, interpreter, American Consulate. Received June 26 and July 7, 1908.

The following seeds:

23336 to 23338. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

23336. *Barchet.* Identical with No. 20798.

23337. *Riceland.* Identical with No. 20797.

23338. *Meyer* (?). Mottled brown. Probably identical with No. 17852.

23339. ORYZA SATIVA L. **Rice.**

23340. LEUCAENA GLAUCA (L.) Benth. Necklace seed.

From Hayden Bridge, England. Presented by Mr. Robert Dodd, Back Row. Received June 27, 1908.

"These seeds are used for making necklaces." (*Safford.*)

23343 and 23344. DIPTEROCARPUS spp.

From Saigon, Cochin China. Presented by Mr. J. E. Conner, American consul. Received July 9, 1908.

23343. DIPTEROCARPUS ALATUS Roxb.

"This is one of the most beautiful trees for street planting and ornamentation that can be found. It is tall, straight as an arrow, has no limbs near the ground, and is both graceful and majestic in appearance. It will grow within thirty years to a height of 100 feet or more, and at maturity attains a much greater height. An avenue of these trees gives the impression of an avenue of royal palms, for the trunks are straight and columnar and present a rather smooth, rounded surface of gray bark reaching far overhead to the beginning of the fan-shaped periphery of limbs and leaves. It is a native of Cochin China only, but has been transplanted to Mexico. The soil is a black alluvial deposit, not too wet." (*Conner.*)

23344. DIPTEROCARPUS INTRICATUS Dyer.

23345 to 23347.

From China. Presented by Rev. J. M. W. Farnham, Chinese Tract Society, Shanghai, China. Received July 9, 1908.

The following seeds:

23345. Fragaria indica Andrews. **Strawberry.**

From Mokanshan, China. "Seed of a wild strawberry. Tasteless." (*Farnham.*)

23346. Rubus sp. **Raspberry.**

"Wild red raspberry found growing 1,600 feet above sea level on the mountain not far from Hangchow, China. A pleasant acid, but not much of the raspberry flavor. Used for eating raw, as jam, and makes a good jelly. A true raspberry." (*Farnham.*)

23347. Rubus sp.

"A wild red berry, resembling the blackberry except in color. Slightly acid." (*Farnham.*)

23348 to 23352.

From China. Received through Mr. Frank N. Meyer, agricultural explorer, in the spring of 1907.

The following plants and seeds:

23348. Ophiopogon japonicus (L.) Ker.

From Tanghsi, China. "(No. 232a, Mar. 1, 1906.) A grasslike plant which may be useful as an edge plant in shady places, as it grows in such locations; bears nice blue berries." (*Meyer.*)

23349. Poa pratensis L.

From Kaiyuan, Manchuria. "(No. 595, Jan. 15, 1907.) A strange grass found growing on the city wall of Kaiyuan. Seems to be able to withstand droughts and neglect remarkably well. Will probably be found to be a very valuable lawn grass." (*Meyer.*)

23350. (Undetermined.) **Sedge.**

From Kaiyuan, Manchuria. "(No. 596, Jan. 15, 1907.) A very slender leaved sedge found growing on the city wall of Kaiyuan, where it is subjected to great extremes in temperature and to much drought. Will probably be found of great use in small gardens in the arid regions as a lawn sedge." (*Meyer.*)

23351. (Undetermined.) **Sedge.**

From Kaiyuan, Manchuria. "(No. 597, Jan. 15, 1907.) A medium slender leaved sedge found growing on the city wall of Kaiyuan. Will be found well fitted for a lawn sedge in the arid regions of the United States. It is probably the same species as that sent from Peking in 1905 under No. 70 (S. P. I. No. 17466)." (*Meyer.*)

23352. (Undetermined.) **Sedge.**

"A very coarse species of low-growing sedge found on the city wall of Kaiyuan. Seems to thrive better in the shady places than when fully exposed to the sun. For this reason it may be of use as a lawn sedge underneath trees. May also be fit as a fodder plant in dry, cold places." (*Meyer.*)

23353 and 23354.

Presented by Miss Jane Lewis, 1721 West Genesee street, Syracuse, N. Y., through Mr. J. R. Robinson, of the Department of Agriculture. Received July 14, 1908.

Seed of each of the following:

23353. Bignonia unguis-cati L.

From Canary Islands. "Seeds of a climber with a lovely yellow flower. They, I believe, will be slow in sprouting." (*Lewis.*)

23353 and 23354—Continued.

23354. GERBERA JAMESONI Bolus. **Barberton daisy.**

From Durban, South Africa. Procured from the curator of the Botanic Gardens. "The flowers are a beautiful shade of red." (*Lewis.*)

23355 to 23363. ANDROPOGON SORGHUM (L.) Brot. **Kafir.**

From Vereeniging, Transvaal, South Africa; original seed from Natal. Presented by Prof. J. Burtt Davy, agrostologist and botanist, Transvaal Department of Agriculture. Received July 21, 1908.

Seed of each of the following. Varietal descriptions by Mr. Carleton R. Ball.

23355. White. Extra long heavy head; seed large, white, slightly flattened; glumes greenish white.

23356. White. Small head as in our domestic varieties; seeds and glumes very similar.

23357. White kafir form. Slender head; white kafir seed, but the greenish white glumes are longer than in a true white kafir.

23358. Medium-sized head; spikelet rather small; glumes reddish to black, about as an orange sorgo; seeds varying from white tinged with red to orange.

23359. Similar to No. 23358, but seeds averaging paler.

23360. Medium kafir head; small orange seeds and greenish glumes tinged with red.

23361. Similar to No. 23360, but glumes frequently a deep red.

23362. Medium kafir head; tinged red seeds and pale glumes.

23363. Medium kafir head, but with deep reddish brown seeds and deep red glumes; strongly resembles a deep red *Orange* or *Colman* sorgo and may prove to be sweet.

23364 to 23366. LITCHI CHINENSIS Sonner. **Leitchee.**

From Canton, Kwangtung, China. Procured by Dr. John M. Swan, medical superintendent, the Medical Missionary Society's Hospital. Received at the Hawaii Agricultural Experiment Station June 6, 1908.

Trees of each of the following:

23364. *Kwai mi.* "A delicious flavored and very popular leitchee. It comes in the fifth lunar month (July). Earliest variety." (*Swan.*)

23365. *Hak ip.* "The black-leaf leitchee; this is a favorite early sort, having a small seed, and is tender and very juicy. It ripens in the fifth lunar month (July), and we count it our best variety. The tree is grafted by the approach system." (*Swan.*)

23366. *Neu mai chi.* "This is the largest fruited and smallest seeded and sweetest leitchee in Canton, and is one of the best. It sells for 10 cents a caddy (about 4 cents a pound), double the price of the ordinary sorts. It ripens in the fifth and sixth lunar months (July and August)." (*Swan.*)

"Leitchees like a rich, clayey soil and must not be allowed to suffer from drought." (*Frank N. Meyer.*)

23367 to 23378.

From Paramaribo, Surinam. Presented by Mr. J. R. Wigman, director of the Botanic Garden. Received July 24, 1908.

Cuttings of each of the following:

23367. CITRUS LIMONUM Risso. **Lemon.**

From Saramacca district.

23367 to 23378—Continued.

23368. CITRUS NOBILIS Lour. **Mandarin.**

From Groningen Station.

23369. CITRUS AURANTIUM L. **Orange.**

From Voorburg estate.

23370. CITRUS AURANTIUM L. **Orange.**

From Groningen Station.

23371. CITRUS DECUMANA (L.) Murr.

"*Curacaosche alamoen.*"

"We consider these trees just as good or in some respects even better than many well-known standard varieties." (*Wigman.*)

23372 to 23378. MANIHOT spp. **Cassava.**

23372.

"*Kankantrie tikie.*"

23373.

"*Kaboegroeoeman.*"

23374.

"*Boeroe tikie.*"

23375.

"*Affie tikie.*"

23376.

"*Pina pina.*"

23377.

"*Ingi bitawan.*"

23378.

"*Bita.*"

"The above yield the largest quantity of starch of any of the Surinam varieties." (*Wigman.*)

23379 and 23380. CARICA PAPAYA L. **Papaw.**

From Ancon, Canal Zone, Panama. Presented by Mr. H. F. Schultz, through Mr. Frederic Chisolm. Received July 21, 1908.

Seed of each of the following:

23379. "Superior variety; large fruit, solid yellow meat; spicy; obovate form; prolific bearer; mother tree at Ancon, Canal Zone." (*Schultz.*)

23380. "Very best variety, producing medium-sized to large fruit; color of meat a golden yellow; flavor excellent, very aromatic; shape of fruit pyriform. Seed obtained from Culebra, Canal Zone." (*Schultz.*)

23381 to 23386.

From Piracicaba, Sao Paulo, Brazil. Presented by Dr. J. William Hart, director, Agricultural College, through Mr. C. V. Piper. Received July 23, 1908.

23381. MELINIS MINUTIFLORA Beauv. **Molasses grass.**

"*Catingueira soxa.* This is the more valuable sort." (*Hart.*)

23382. ANDROPOGON HALEPENSIS (L.) Brot. **Johnson grass.**

"This stock does not spread by means of roots." (*Hart.*)

23381 to 23386—Continued.

23383 and 23384. "Seed of two coarse-growing forage grasses." (*Hart.*)

23383. Panicum sp.

"*Capim milhã branca de Itapira.*"

23384. Panicum sp.

"*Capim Guine.*"

23385. PANICUM MAXIMUM Jacq. **Guinea grass.**

"*Capim colonia.* This is a rank grower and makes a quantity of hay that all classes of stock eat eagerly. In our alfalfa field it is the most persistent 'weed' that we have to contend with. Usually it is in flower every time the alfalfa is cut, and the combination beats timothy and clover." (*Hart.*)

23386. MARANTA ARUNDINACEA L. (?) **Arrowroot.**

"This is much superior to the common arrowroot we have been growing; is very large and easier to dig on account of its bulbs being near the surface. It might be of some value where the common Bermuda arrowroot flourishes." (*Hart.*)

23390. TRICHOLAENA ROSEA Nees.

From Piracicaba, Sao Paulo, Brazil. Presented by Dr. J. William Hart, director, Agricultural College, through Mr. C. V. Piper. Received July 27, 1908.

"*Favorite* grass. A very fine hay grass. It does not grow in clumps like so many of our grasses, and may prove a good lawn grass for the South." (*Hart.*)

23391 and 23392.

From Spain. Received through Mr. M. Fraile, of this Department, July 28, 1908.

23391. MEDICAGO SATIVA L. **Alfalfa.**

"These roots of 'Mielga' were only sent to show the size, and were taken from the roadside near the village of Villares de la Reina. This plant remains green through drought, while other small vegetation withers away." (*Fraile.*)

"The name 'Mielga' is never applied to the cultivated form of alfalfa, but only to the wild form. Some seedsmen also apply it to *Medicago sativa varia.*

"The plants lack the upright habit of cultivated alfalfa, and are viewed very much as weeds are in this country. Frequently it is quite difficult to eradicate them from fields in which they have become established. The roots sometimes acquire a diameter of an inch or more." (*Brand.*)

23392. AMYGDALUS COMMUNIS L. **Almond.**

"Cuttings of seedling hard-shelled almonds from along the railway track near Bobadilla. These trees were planted by the railroad company, and extend from Bobadilla 50 miles northward. They are now (1908) 13 years old and are bearing fruit. This is the most colossal seedling orchard of these seedling hard-shelled almonds in the world, and the late-flowering varieties are worthy of being picked out and propagated." (*Fairchild.*)

23393. SOLANUM JAMESII Torr.

From Santa Fe, N. Mex. Presented by Mr. M. J. Nagle, through Mr. R. A. Oakley. Received July 18, 1908.

See Nos. 10473 and 18342 for previous introductions.

23395. LITCHI CHINENSIS Sonner. Leitchee.

From Nodoa, island of Hainan, South China. Presented by Mrs. L. E. M. Kelly, Hoihow, island of Hainan, South China, via Hongkong. Received August 1, 1908.

23395—Continued.

"This shipment contains five different varieties of leitchees. The seeds were taken from selected fruits of the most delicious kinds and have been dried in the shade, as the Chinese say they will never grow if dried in the hot sun. In planting, the seeds must be barely covered with finely pulverized earth and watered freely." (*Kelly.*)

23416. PITHECOLOBIUM DULCE (Roxb.) Benth.

From Tamaulipas, Mexico. Presented by Mr. Clarence A. Miller, American consul at Matamoros, through Mr. E. C. Green, in charge of the South Texas Garden, Brownsville, Tex., at the request of Mr. Frederic Chisolm. Received August 3, 1908.

"A plant used for tanning purposes. These seeds were secured from a small tree growing in the State of Tamaulipas, Mexico. The trees occur occasionally through the northern part of that State." (*Green.*)

23417 to 23422. ANDROPOGON SORGHUM (L.) Brot. **Sorghum.**

From Natal, South Africa. Presented by Miss Caroline E. Frost, Umzumbe Mission Station. Received August 1, 1908.

The following seeds. Varietal descriptions by Mr. Carleton R. Ball.

23417. **Kafir.**

"*Ibele elimhlope.* Tall, bears well, eaten by birds more than other kinds." (*Frost.*)

Very slender head near *Blackhull* kafir, but spikelets smaller and grain has pinkish tinge.

23418. **Kafir.**

"*Ibele elifupi.* A favorite variety among Zulus because it is short and easy to handle." (*Frost.*)

A large heavy head near *Red* kafir, but glumes are greenish white and seeds pale red.

23419. **Sorgo (?).**

"*Ihlosa.* Tall; eaten by birds." (*Frost.*)

A loose, open, medium-sized head with slender branches; rachis extending only halfway through; glumes mostly shining black, and obovate seeds of a pinkish tinge. Pith discolored.

23420. **Sorgo (?).**

"*Njiba.* Tall, rather bitter; larger seeds than other varieties; not eaten by birds." (*Frost.*)

Short, oval head; rachis 1 inch long; branches stout at crest; glumes short, mostly greenish white; obovate, pale red seeds; resembles our *sumac-milo* hybrid.

23421. **Kafir.**

"Apparently the same as the second variety (S. P. I. No. 23418)." (*Frost.*)

Small, slender head; greenish glumes and large obovate pink seeds.

23422.

"*Coolie corn.* This grows larger and taller than any of the other varieties, eaten by birds." (*Frost.*)

Probably not native to Natal, a form of Hackel's variety *roxburghii*, to which *shallu* belongs. Characterized by long, loose head; long slender branches; slender, acute, greenish to red glumes, spreading apart and becoming involute at maturity, completely exposing the flattened, oval, white seed, which shatters readily; strongly awned; almost identical with some *mpembys.*

23423 and 23424. PHOENIX spp.

From Nice, France. Presented by Dr. A. Robertson Proschowsky. Received July 27, 1908.

23423 and 23424—Continued.

23423. PHOENIX CANARIENSIS Chabaud. (?)

"This beautiful palm, considered by Prof. U. Dammer, of Berlin, a distinct species (I could not find out origin), produces fairly good dates and will, I think, interest Mr. Swingle, who has asked me for seed of my different Phoenix with eatable fruits for hybridization purposes." (*Proschowsky.*)

23424. PHOENIX RECLINATA Jacq. (?)

"Stem short; leaves 2-ranked, bright green, obliquely arcuate-recurved toward the apex; leaflets rigid, 12 inches long, 1 inch wide, lanceolate, acuminate, the lowest spinescent." (*Bailey.*)

23425 to 23431.

From Rio de Janeiro, South America. Presented by Dr. Wenceslão Bello, president of the National Society of Agriculture. Received July 31, 1908.

The following plants:

23425. CHUSQUEA BAMBUSAEOIDES (Raddi) Hackl. (?)

"*Taquarussú.* A kind of bamboo bearing abundant seed and occurring in the neighborhood of Rio." (*Bello.*)

23426. MANGIFERA INDICA L. **Mango.**

"*Itamaracá.* A small yellow mango with thin skin, without fiber, and of very delicate flavor, bringing a high price on the market. Occurs in Pernambuco." (*Bello.*)

23427. PLATONIA INSIGNIS Mart.

"*Bacopari.* This fruit is slightly acid, has a white pulp, and is probably a wild form." (*Bello.*)

23428. MYRCIARIA EDULIS (Vell.) Skeels (EUGENIA EDULIS Vell.).

"*Cambucá.* A very large tree with fruit the size of an apple, of yellow color, much more delicate than the guava." (*Bello.*)

23429 to 23431. MYRCIARIA CAULIFLORA (Mart.) Berg.

"*Jaboticaba.* Bears a small black fruit about the size of a plum, of a delicious flavor." (*Bello.*)

23429. Var. *coroa.*

23430. Var. *murta.*

23431. Var. *paulista.*

23432 to 23435.

From Jamaica Plain, Mass. Presented by Prof. C. S. Sargent, of the Arnold Arboretum. Received at the Subtropical Laboratory and Garden, Miami, Fla., August 4, 1908.

The following plants:

23432. OROXYLON FLAVUM Rhed.

A tree, with light brown bark. Flowers clear sulphur yellow, appearing in spring.

"This species will probably be suited to the climate of the Southern States and of southern California, and will be a desirable ornamental tree on account of its large pinnate foliage and handsome yellow flowers." (*Rheder.*)

23433. DORYANTHES PALMERI W. Hill.

"An amaryllus-like herb. Flowers red, in an oblong, branched raceme, 3 feet long, stem and bracts the same rich color as the flowers. A native of Queensland, Australia." (*Bentham, Flora Australiensis.*)

23434. SCHEFFLERA sp. (?)

23435. FICUS PANDURATA Hance.

"A low diffuse bush, with large broad leaves, from southern China." (*Annals of Calcutta Botanic Gardens, 1887–88.*)

"It is of use as a greenhouse ornamental, and as such has been known to reach a height of 14 feet." (*Young.*)

23436. COLCHIUM AUTUMNALE L. **Meadow saffron.**

From York, England. Purchased from J. Backhouse & Son (Limited) for Dr. R. H. True's experiments. Received August 11, 1908.

"A low, perennial, bulbous plant, native in moist meadow lands in middle and southern Europe. The corms and seeds are used in preparing the extract and wine of colchicum and the alkaloid colchicun and its salts, employed in the treatment of gout.

"Cultivated as an ornamental. Flowers in autumn.

"This plant possesses very active properties, a small portion of the root or seeds taken internally being sufficient to cause poisoning." (*True.*)

23437. GLADIOLUS spp. **Gladiolus.**

From Pretoria, South Africa. Presented by Prof. J. Burtt Davy. Received August 7, 1908.

"Corms of our native gladioli. There is more than one species represented in this collection." (*Davy.*)

23438 to 23446.

From Bagdad, Turkey. Procured by Mr. William C. Magelssen, American consul. Received August 11, 1908.

The following seeds:

23438. PHOENIX DACTYLIFERA L. **Date.**

Ascherasi.

23439 to 23446. ZIZYPHUS JUJUBA (L.) Lam. **"Nabuk."**

23439.	*Ascherasi.*	**23443.**	*Khadrawi.*
23440.	*Khastawi.*	**23444.**	*Zeytouni.*
23441.	*Zehdi.*	**23445.**	*Jozi.*
23442.	*Berben.*	**23446.**	*Taberzal.*

"The foliage of the Nabuk tree appears to be equally luxuriant on all varieties, and there is no choice so far as their growth is concerned. The fruit differs slightly in taste and quality; it is eaten by the poorer classes of Mohammedans and Jews. I am informed that the natives make it a practice to soak the seed in rose water before planting, claiming that this tends to increase the beauty of the tree and the flavor of the fruit. The Nabuk is certainly the finest shade tree grown in these parts, and I judge from the scant care given it that the tree must be an exceptionally hardy one." (*Magelssen.*)

23449. AMYGDALUS PERSICA L. **Peach.**

From Pretoria, Transvaal. Presented by Mr. R. A. Davis, government horticulturist, Transvaal Department of Agriculture. Received August 13, 1908.

"These seeds are from a natural variety, *St. Helena*, or *Transvaal Yellow*, always coming true. As a fruit, they are a good cling canner, but otherwise useless. As a stock, they are unequaled for wet, dry, rocky, or loamy soil; will germinate and fruit in two years if thrown from a railway carriage window into a rocky crevice. I think it should be very useful in California." (*Davis.*)

23450. AGATHIS AUSTRALIS (Lamb.) Steud. **Kauri pine.**

From Auckland, New Zealand. Presented by Mr. D. Petrie. Received August 13, 1908.

"This magnificent tree measures, under favorable circumstances, 180 feet in height and exceptionally 17 feet in diameter of stem, the estimated, but perhaps overrated, age of such a tree being 700 to 800 years. It furnishes an excellent, remarkably durable timber, straight grained, and much in use for

23450—Continued.

masts, boats, superior furniture, casks, and rims of sieves, and it is particularly sought for decks of ships, lasting for the latter purpose twice as long as the deal of many other pines. It is also available for railway brake blocks and for carriages, and is regarded as one of the most durable among timbers of the Coniferæ. * * * This tree yields, besides, the Kauri resin of commerce. * * * The varnish made of it is almost colorless." (*Extract from von Mueller.*)

23451. ARISTOTELIA MACQUI L'Herit. **"Maqui."**

From Santa Ines, Chile. Procured from Salvador Izquierdo. Received August 18, 1908.

"Seed of the Chilean shrub which is so much used for giving color to pale wines. The color is extracted from the berries or seeds by trituration, maceration, and, finally, decantation." (*Izquierdo.*) (See also No. 19113 for further description.)

23452. RUBUS SPECTABILIS Pursh. **Salmon berry.**

From Sitka, Alaska. Received through Prof. C. C. Georgeson, special agent in charge, Agricultural Experiment Station, August 18, 1908.

"The salmon berry of Oregon, California, and New Mexico. Closely allied to *R. nutkanus*, but the stem is nearly evergreen, and ramification persistent and prickly. Fruit large, red, yellow, or salmon colored, raspberry-like. Mr. L. Burbank records that the stems will reach a height of 20 feet and occasionally a foot in diameter. Fruit larger than any raspberry, but not so well tasted. Crop always abundant. Fruit ripe when other raspberries are only in bloom. [Prof. Meehan.] Requires moist, sandy land. Promising for hybridization." (*Von Mueller.*)

23453. VOANDZEIA SUBTERRANEA (L.) Thouars. **Woandsu.**

From Pretoria, Transvaal, South Africa. Presented by Prof. J. Burtt Davy, Transvaal Department of Agriculture. Received August 7, 1908.

"African groundnut, African ground pea, woandsu, and erroneously goober pea.

"Native of Madagascar, Comoro Island, and various parts of Africa as far south as Natal. A plant very much resembling the peanut, but containing only one seed in each pod. These pods ripen under the ground in the same manner as peanuts. The plant is smaller, and in most cases not so prolific in seed as the best varieties of peanuts. These are used in about the same manner as peanuts both for human food and as feed for animals. In California the woandsu has yielded nearly as heavily as the best varieties of peanuts, but at most other places the yield has been less." (*C. V. Piper.*)

23455. ZIZYPHUS SATIVA Gaertn. **Chinese date.**

From Beaufort, S. C. Purchased from Mr. A. P. Prioleau, through Mr. Frederic Chisolm, for stocks. Received August 20, 1908.

"This fruit, commonly called jujube, is very pleasant eaten raw, and is largely used in the Southern States in making jujube paste and similar confectionery. The fruits are dried by the Chinese, and in that condition taste somewhat between a raisin and a dried date." (*Chisolm.*)

23456. (Undetermined.)

From Nodoa, island of Hainan, South China. Presented by Mrs. J. Franklin Kelly, Hoikow, island of Hainan, South China. Received August 29, 1908.

"Seed of the 'yellow-skin' (*Iu Foc*), a fruit the size of a large marble, yellow skin when ripe, with a tart, delicious flavor. It makes a nice, cooling drink and lovely jam, a little like gooseberry in flavor. It grows on a pretty, symmetrical tree." (*Kelly.*)

23457. PITHECOLOBIUM DULCE (Roxb.) Benth. **Guamuchitl.**

From Ixtlan del Rio, Tepic, Mexico. Presented by Sr. Alfredo Lonergan, through Mr. Frederic Chisolm. Received August 11, 1908.

"A thorny leguminous tree known in Mexico as guamuchitl, or huamuchitl; the sweetish pulp of the pods is universally eaten by the natives, while the bark of the tree is used in tanning leather. Has succeeded at Miami, Fla." (*Chisolm.*)

23458 to 23467. MEDICAGO SATIVA L. **Alfalfa.**

From Peru. Procured by Mr. T. F. Sedgwick from Antonio Cantelli Y Hno, Lima, Peru, for Mr. C. V. Piper. Received August 19, 1908.

23458. *Barranca.*
23459. *Conchapilea.*
23460. *Pueblo Nueva.*
23461. *Cochahuiaico.*
23462. *Omas.*
23463. *Monsefu.*
23464. *San Pedro.*
23465. *Acos.*
23466. *Supe.*
23467. *Saýan.*

23468 and 23469.

From Salamanca, Spain. Secured by Mr. Manuel Fraile, of this Department. Received August 24, 1908.

23468. MEDICAGO SATIVA L. **Alfalfa.**

Roots from plants growing beside road between Salamanca and Villares de la Reina, Spain. (See No. 23391 for further remarks.)

23469. AMYGDALUS COMMUNIS L. **Almond.**

Hard-shelled sweet variety. From a tree 30 years old growing in a garden in Villamayor, Salamanca, Spain.

23471 to 23473.

From Cochin China. Presented by Hon. Jacob E. Conner, consul. Received August 25, 1908.

The following seeds:

23471. AVERRHOA BILIMBI L. **Cucumber tree.**

"Flowers red in larger racemes than *A. carambola;* fruit smaller than carambola, cucumber shaped, smooth, green rind, and acid pulp. Extensively cultivated in South America." (*L. H. Bailey.*)

23472. PHYLLANTHUS ACIDA (L.) Skeels (AVERRHOA ACIDA L.). **Otaheite gooseberry.**

"Shrub, with ovate acute leaflets; flowers on separate branches below the foliage; fruit fleshy, edible. India and Madagascar. W. Harris, of Hope Gardens, Jamaica, West Indies, writes that the Otaheite gooseberry is an elegant shrub or small tree, often cultivated in gardens in the lowlands of Jamaica and the West Indies. The fruit is very acid and astringent; the root is an active purgative, and the seed is also cathartic. The fruit is occasionally pickled or made into preserves. Plants are raised from seeds." (*L. H. Bailey.*)

23473. AVERRHOA CARAMBOLA L.

From tree growing in Mr. Conner's garden. "The fruit is quite juicy, piquant, and agreeable. As the plant can stand slight frost it ought to succeed in southern Florida. The fruit is well worthy of introduction." (*Conner.*)

23474. Illipe latifolia (Roxb.) F. Muell. **Mahwah.**

From Baroda, India. Presented by M. A. Sitole, Director of Agriculture, Baroda State, India, through Mr. O. W. Barrett. Received August 20, 1908.

"A tree, growing 50 feet high, content with dry, stony ground, enduring slight frost. Wood so tough as to be adapted for plows and various machinery [Dr. Schlich]. The succulent corolla affords a never-failing crop of nourishing saccharine food to the rural inhabitants. Each tree supplies 2 to 3 hundredweight; each hundredweight yields on distillation about 3 gallons of spirits; essential oil is also obtained from the corolla. The flowers are also used for feeding cattle; they will keep for a long time. The seeds yield oil of thick consistence." (*Von Mueller.*)

23475. Paspalum dilatatum Poir. **Large water grass.**

From Coffs Harbor, New South Wales, Australia. Purchased from Mr. W. Seccombe, through Mr. C. V. Piper. Received August 22, 1908.

23476. Dendrocalamus strictus (Roxb.) Nees. **Bamboo.**

From British India. Presented by Mr. Jean Houzeau de Lehaie, Saint Symphorien, Belgium. Received August 26, 1908.

"One of the most valuable bamboos; is not hurt by slight frosts and, it is said, is very drought resistant. Wood of the finest quality.

"I hope that this valuable species, designated by Sir D. Brandis as the most important for the Southwest of the United States, has now been introduced in sufficient quantity so that a distribution may be made for outdoor planting. I think that in order to be successful the young plants ought not to be planted outdoors until the spring of 1910, unless it is under exceptionally favorable conditions, and that in any case it will be necessary to irrigate or water them, to fertilize them, and to keep them covered with straw the first summer after they are planted out. It will of course be only the most vigorous and well rooted plants which will show all their power of resistance and all their good qualities." (*De Lehaie.*) (See Nos. 21548 and 22819 for previous importations.)

23477. Vitis vinifera L. **Grape.**

From Aberdeen, Cape Colony, South Africa. Presented by Mr. F. W. Eagle, at the request of Mr. R. A. Davis, government horticulturist, Transvaal Department of Agriculture. Received August 29, 1908.

Karroo Belle. "This grape is a really good table fruit, possessed of hardy qualities and largely resistant in this country to *oidium;* it would be quite at home in the Santa Clara Valley, and also, I think, farther south, even in Fresno." (*Davis.*)

"I have succeeded in rearing a cross between the vines *White Crystal* and *Muscat Hambro*, which I have named *Karroo Belle.* A magnificent grape, strong grower, enormous cropper, very large and most compact bunches (some cut this season weighed from 5 to 7½ pounds), round and very large, almost stoneless berries, which are a dark brownish purple where well exposed to the sun, but where hanging in the shade are only slightly tinted, or even quite green if very much shaded, and always with a great deal of bloom. Carries exceptionally well, as proved by a box of grapes sent to Johannesburg containing eight varieties, among which were *Hannepoot, Crystal Muscat Hambro, Uitenhage Blue*, etc., all of which were useless except *Karroo Belle*, bunches of which were perfect. As regards keeping qualities, we cut the first ripe bunch off the parent vine on January 15, and the last one on June 28, which were perfectly sound except a few berries stung by the bees through the bag, so that we have been cutting grapes from the one vine for nearly five and a half months." (*Mr. Eagle, Aberdeen, Cape Colony, in the Transvaal Agricultural Journal, January, 1907, p. 472.*)

"This variety of grape has been planted largely in different districts of the Transvaal. The vine arrived with a flattering reputation, but has, unfortunately, proved in the majority of cases quite worthless, owing to the fact that

23477—Continued.

it bore no fruit. The writer in the course of his journeys through the country has only found two of the kind which ever gave signs of a crop, one of which has been grown by Mr. J. G. Beverley, of Zeerust. This particular vine has at present (in its third year) 59 bunches of grapes well formed and set and in perfectly healthy condition. It would appear, therefore, that this grape, one of the few varieties originated in South Africa, will under certain circumstances do exceedingly well." (*Extract from the Transvaal Agricultural Journal, January, 1907, p. 471.*)

23481. MEDICAGO SATIVA VARIA (Mart.) Urb. **Alfalfa.**

From Hamburg, Germany. Purchased from R. Liefman Sons, Successors, through Mr. I. L. Radwaner, 533 East 149th street, New York. Received August 31, 1908.

Sand lucern.

23482. VICIA VILLOSA Roth. **Hairy vetch.**

From Svalof, Sweden. Purchased from the Allmanna Svenska Utsadesaktiebolaget, through Dr. Albert Mann, at the request of Mr. A. D. Shamel. Received July, 1908.

To be used by Mr. A. D. Shamel, at Hockanum, Conn., as a cover crop in his tobacco experiments.

23483. DAHLIA sp. **Dahlia.**

From Erfurt, Germany. Purchased from Mr. T. C. Schmidt. Received September 3, 1908.

"Variety *coronata*. This Mexican sort is to be regarded as a forerunner of quite a new class and certainly worth consideration, especially as the flowers have a pleasant honey-like scent, which up to the present no other dahlia has. The habit and growth of the plants are somewhat different from the other known dahlia sorts, because they first nearly fully develop and then bring up the enormously long flower stems, so that the flowers are from 20 to 28 inches freely above the foliage. The whole plant reaches a height of about 4½ feet, blooms abundantly, and one can easily cut flowers with stems 24 to 30 inches long, which makes this sort valuable for large bouquets, especially as the cut flowers keep in water several days.

"The color of the flowers is a brilliant and bright scarlet, the form that of the single dahlias, only the separate leaves are bent somewhat inward, and besides that the flowers close in the evening, assuming thereby the form of a crown. The raising from seed is not at all difficult. By sowing in May the plants bloom in July and August." (*Schmidt.*)

23485 and 23486.

From Stockholm, Sweden. Presented by Dr. Veit Wittrock, director, Botanic Garden. Received August, 1908.

Seed of each of the following:

23485. VICIA KOKANICA Reg. & Schmal.

"A perennial species occurring in the mountains of Kokan near Woruch, Naubid, and in the passes of Basmandinsk (Turkestan)." (*O. Fedtschenko, in Fedtschenko's Journey in Turkestan, vol. 3.*)

23486. PHLEUM PRATENSE NODOSUM (L.) Halacsy.

23487. PHALARIS COERULESCENS Desf.

From Melbourne, Australia. Presented by Mr. Alfred Henry, Office of Titles, Queen street, through Mr. C. V. Piper. Received August, 1908.

See No. 22961 for description.

23488. ANDROPOGON HALEPENSIS (L.) Brot. **Johnson grass.**

From Brazil. Presented by Mr. H. M. Lane, president, Mackenzie College, Sao Paulo, Brazil, through Mr. C. V. Piper. Received August 24, 1908.

"This seed was procured from a seedsman and is probably from one of the northern States of Brazil. It does not grow here (Sao Paulo)." (*Lane.*)

23489 to 23493.

From Cordoba, Spain. Received through Mr. Manuel Fraile, of this Department, September 4, 1908.

23489. PUNICA GRANATUM L. **Pomegranate.**

Sweet.

23490. PUNICA GRANATUM L. **Pomegranate.**

Sour.

23491. AMYGDALUS COMMUNIS L. **Almond.**

Sweet.

23492. AMYGDALUS COMMUNIS L. **Almond.**

Bitter.

"These almonds are said to flower in April and May, but as the region from which they come is a rather cool one they probably should not be regarded as late-flowering varieties." (*Fraile.*)

23493. CROCUS SATIVUS L. **Saffron.**

23494. CUCURBITA PEPO L. **Squash.**

From Philippine Islands. Presented by Mr. W. S. Lyon, Manila, P. I. Received August 26, 1908.

"*Calabaza.* This plant was found growing on a house in a barrio of a small town on the shores of the Laguna de Bay, Luzon. The leaves are not unusual in shape, but the center of each is of the richest gold or orange yellow surrounded by a zone of the darkest and blackest of vegetable greens. The fruit from which these seeds were obtained was rather small, weighing only about 2 pounds, with a major diameter of 6½ inches and a minor of 4½ inches. The fruit has all the sweetness, dryness, and chestnut-like flavor of the best strains of the *Winter Hubbard* squash. Externally the skin is smooth, the central zone being of a dark rich green, on each side of which is an orange-yellow cap. It looks more like a striking fancy gourd than a squash. The owner of the vine from which I obtained the single fruit claimed that no one else owned a similar plant, as he had always refused to sell mature fruits or seeds. From the appearance of the vine I believe that it is a shy bearer, which does not lessen the value of the plant as an ornamental of a very unusual character." (*Lyon.*)

23495. EUCALYPTUS MICROTHECA F. Muell. **Coolibah.**

From Sydney, New South Wales, Australia. Procured from Mr. J. H. Maiden, director and government botanist, Botanic Gardens. Received September 8, 1908.

"Widely dispersed over the most arid extratropical as well as tropical inland regions of Australia. The 'coolibah' of the aborigines, according to the Rev. Dr. Woolls. The tree wants ferruginous-gravelly soil, perfectly drained. Withstands unscorched a frequent heat of 156° F. in Central Australia, yet was not affected by exceptionally severe frosts (18° F.) in the south of France when many other eucalypts suffered. The development of this species in southern France and Algeria has been marvelously quick. [Prof. Naudin.] One of the best trees for desert tracts; in favorable places 150 feet high. Wood brown, sometimes very dark, hard, heavy, and elastic; it is prettily marked, hence used for cabinetwork, but more particularly for piles, bridges, and railway sleepers. [Rev. Dr. Woolls.]" (*Von Mueller.*)

"This seed was introduced partly for raising trees for honey in California." (*Young.*)

23496 to 23518.

From Yokohama, Japan. Presented by the Yokohama Nursery Company. Received August 14, 1908.

The following seeds from the Jingpoo Chrysanthemum Garden. Japanese names quoted:

23496 to 23502. CHRYSANTHEMUM STIPULACEUM (Moench) W. F. Wight.

23496. "*Shiro-mame.*"

23497. "*Kangiku.*"

23498. Best pink.

23499. "*Kyo-miyage.*"
Pink.

23500. "*Nure-garasu.*"
Pink.

23501. "*Murasaki-no-kuruimono.*"
Purple.

23502. "*Oritaki-shiba.*"
Purple.

23503. ASTER sp. (?)

Purple.

23504 to 23518. CHRYSANTHEMUM STIPULACEUM (Moench) W. F. Wight.

23504. "*Hano-no-seki.*"
Purple.

23505. "*Shukokin.*"
Red.

23506. "*Uji-no-sato.*"
Red.

23507. "*Bushi-no-kagami.*"
Red.

23508. "*Date-musume.*'
Red.

23509. "*Okino-kaza.*"
White.

23510. "*Fuki-no-yama.*"
White.

23511. "*Okina-no-tomo.*"
White.

23512. "*Matsu-no-yuki.*"
White.

23513. "*Gano-no-yuki.*"
White.

23514. "*Hakuhoshu.*"
White.

23515. "*Jitsugetsu.*"
White and purple mixed.

23516. Yellow.

23517. "*Kin-kujiyaku.*"
Yellow.

23518. "*Azami.*"
Yellow.

23519 and 23520. GARCINIA spp.

From Buitenzorg, Java. Presented by Dr. M. Treub. Received September 4, 1908.

23519. GARCINIA BENTHAMI Pierre.

"This species is very widely distributed in all the provinces of lower Cochin China and Cambodge.

"Branches opposite, tetragonal, very long. Leaves petiolate. The flowers are terminal at the summit of a short shoot more or less surrounded with bracts. They are solitary in the female plant. The petals are broader and thicker than the sepals and are yellowish. In the female flowers the stamens are completely lacking and the gynaeceum has the form of a pear. The fruit retains the form of the pistil. It contains 5 to 10 seeds having the form of a crescent.

"The tree is 20 to 25 meters high, of pyramidal form. Trunk straight, 45 to 50 centimeters thick, covered with a blackish bark, rough exteriorly, filled interiorly with a white juice, present in all parts of the plant and becoming black on exposure to light.

23519 and 23520—Continued.

"The wood of *G. benthami* is reddish brown and very much esteemed. It is used for the same purposes as that of *G. ferrea* and differs from it very little. If we consider what Rumphius says about that of *G. celebica* L., we may regard it as established that all the Garcinias with a white juice have reddish brown or honey-colored wood superior to that of the other species of Garcinia. This observation is important for forest cultivation." (*Extract from Pierre's Forest Flora of Cochin China.*)

23520. GARCINIA CELEBICA L.

"This tree grows very quickly and without difficulty. The leaves have an acid flavor; the fruits remain acid a long time; their taste when they are perfectly ripe is somewhat like that of the cultivated mangosteens. An excellent jelly is made of them and a refreshing pectoral sirup which Lamarck says is in daily use at Mahé. Its fruits are used in dyeing, and their rind has astringent properties and serves to make vinegar. A viscid, milky, yellowish juice runs from incisions made in the tree, which gives a species of gum. This mangosteen grows naturally in the East Indies and is also found in the island of Bourbon and in several of the Antilles.

"It is not a very tall tree and has a large tufted top. The branches are glabrous, a little striate, slightly tetragonal, and covered with a grayish or dull red bark. The leaves are opposite, numerous, oval-lanceolate, pointed at the two ends, glabrous, green on both sides, much narrower and less thick than those of the cultivated mangosteen. The flowers are unisexual and borne on different plants. The female flowers are terminal, solitary, hardy pedunculated. The fruit is globular, of a yellowish red or saffron color, sometimes violet, crowned by the stigma; it is a little bit larger than the 'pomme d'api,' which it resembles in form.

"The yellow juice which comes from incisions in this mangosteen gives a kind of aromatic resin, sought after for medicinal purposes. The fruit furnishes a balsamic acid, and the bark tannin." (*Extract from the Medical Flora of the Antilles, by Descourtilz.*)

"These two species of Garcinia were introduced for testing as stocks on which to grow the mangosteen, which is notably one of the weakest rooted plants of this genus." (*Fairchild.*)

23522 to 23525.

From Chungking, west China. Presented by Rev. J. F. Peat. Received August 24, 1908.

Seed of each of the following. Varietal descriptions by Mr. H. T. Nielsen.

23522. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

Greenish yellow with dark hilum.

23523. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

Black. Similar in appearance to No. 19183.

23524. VIGNA SESQUIPEDALIS (L.) W. F. Wight.

Red.

23525. PISUM ARVENSE L. **Field pea.**

23526. GOSSYPIUM HIRSUTUM L. **Cotton.**

From Carácas, Venezuela. Presented by Dr. E. André, Port of Spain, Trinidad, British West Indies. Received August 28, 1908.

"A curious variety." (*André.*)

"Lint medium short staple length, drag very fine, of great strength. Probably a tropical cotton adapted to only tropical regions." (*D. N. Shoemaker.*)

23527. MUSA PARADISIACA L. **Banana.**

From Ambos, Camarines, P. I. Presented by Mr. William S. Lyon, Manila, P. I. Received September 8, 1908.

"Seed of an edible species. The fruit is large and well flavored and the farinaceous seeds are quite tender and eaten, not rejected, when the fruit is ripe. They do not harden until the fruit begins to decay. It is one of our many

23527—Continued.

varieties, and I can give you no specific or even local name other than 'sagin,' but as sagin is Tagalog in general for banana, it does not amount to much." (*Lyon.*)

23528. FICUS CARICA L. **Fig.**

From Nodoa, island of Hainan, China. Presented by Mrs. J. F. Kelly, Hoihow, island of Hainan. Received September 8, 1908.

Seeds of a Chinese fig.

"Color when ripe dark red. Grows beside running water. Figs grow on trunk of tree near base. Fruit is cool and delicious. Diameter as much as 3¼ inches; outside pulp 1 inch thick and a large ball of white custard in the center surrounded by seeds." (*Kelly.*)

23529 and 23530. ACACIA spp.

From Chico, Cal. Procured by Mr. W. W. Tracy, jr., in charge of Plant Introduction Garden. Received September 3, 1908.

Seed of each of the following:

23529. ACACIA LONGIFOLIA (Andr.) Willd.

Seeds from tree on Mr. Bidwell's place at Chico, Cal. For trial at Brownsville, Tex.

"A bushy Acacia useful in Australia for binding coast sands through the facility with which the lower branches throw down roots into the soil. The bark, while not so high in tannin as that of *Acacia mollissima*, is used chiefly in tanning sheep skins." (*Extract from von Mueller.*)

23530. ACACIA MOLLISSIMA Willd.

Seed procured from trees thriving in the streets of Chico, Cal. To be tested in the open at Brownsville, Tex.

"The black wattle of southeastern Australia and Tasmania. An Acacia thriving on the poorest soil and producing a bark so high in tannin as to render its cultivation very profitable, especially in Natal, where large plantations have been established on the rolling uplands; as a tan producer it is by far the most valuable of the Acacias, and the bark is especially valuable for tanning sole leather and heavy goods." (*Extract from von Mueller.*)

23531 to 23534. RUBUS spp.

From Mokanshan, China. Presented by Rev. J. M. W. Farnham, Shanghai, China. Received September 5, 1908.

Seed of each of the following:

23531 and 23532.

"These grow on the stem like the blackberry and have no core like the raspberry. They are both red, with a pleasant acid flavor, and might become fruitful and useful if cultivated in a proper location, or they may be useful in hybridizing experiments." (*Farnham.*)

23533.

"I found these growing wild and noticed that they resembled what I remember seeing in New England and heard called 'English black raspberry.' I transplanted some to the garden, but was told that they did not bear fruit. However, I persevered in cultivating them and they commenced bearing, and the berries have improved in size and quality until this year. Many of them were of good size and flavor." (*Farnham.*)

23534.

"These seeds are from a bush I am cultivating that I found growing wild here on the mountain 2,000 feet above the sea. It resembles the raspberry in that the lobes of the berry are arranged around a core, or center, but the vine is more like the blackberry, though the leaves are very light on the under side, almost white, like the raspberry. The lobes are slightly acid and red. They are very few at present, but I hope will increase in number with cultivation." (*Farnham.*)

23535. INDIGOFERA GLANDULOSA Wendl. **Befri.**

From Baroda, India. Procured by Mr. William H. Michael, American consul-general, Calcutta, India, through Lieut. Col. M. J. Meade, C. I. E., superintendent, Baroda Presidency. Received September 4, 1908.

"The befri plant is an annual and belongs to the natural order Leguminosæ. It generally grows in black soil, and does not require much water. Befri is contained in very small pods, which are gathered after the rainy season is over.

"Befri contains 21.13 per cent of albuminoids, whereas their proportions in Indian wheat and oatmeal are, respectively, 13.50 and 16 per cent. In other words, befri is 56 per cent more nutritious than wheat and 32 per cent more so than oatmeal. It is ground, mixed with flour of bajri or other less nutritious grains or grass seeds, and made into bread, bhedki, etc." (*Shamsudin J. Sulemani, chief medical officer of Baroda State.*)

23536. CANARIUM LUZONICUM (Blume) Gray. **Pili nut.**

From Tayabas Province, P. I. Presented by Mr. William S. Lyon, Manila, P. I. Received September 8, 1908.

"I sent some of these nuts to a New York fruit seller some five years ago, and in his opinion they rivaled the famous Brazil nut (*Bertholetia*) as a dessert nut. He, however, expressed an adverse opinion of their ever having any commercial value as dessert nuts, owing to the hard shell resisting any ordinary hand nutcracker.

"In a lot I picked up in Tayabas I found two or three which, though far from having paper shells, were amenable to my heel on a board floor. I thought the matter worth looking up, and ascertained that they came from the neighborhood, and spent a few days collecting fruits from all the fruiting trees in the vicinity. Although I made no 'find,' I send on the fresh collected seeds for you to grow as stock in case I am able to secure later scions of the paper-shell variety." (*Lyon.*) (See No. 21860 for previous importation.)

23542. CUCUMIS MELO L. **Muskmelon.**

From Paris, France. Presented by Mr. W. W. Keen, 1729 Chestnut street, Philadelphia, Pa. Received August 26, 1908.

"Seed of melons now so abundant here (Paris). They are much larger than our cantaloupe and of quite as fine a flavor, if not even better. The interior is a beautiful reddish yellow." (*Keen.*)

"This is probably one of the varieties of the large Persian melons which do not thrive in this region (Washington, D. C.), but do much better in the hot, dry climate of Colorado and westward." (*W. W. Tracy, sr.*)

23543. PHASEOLUS VULGARIS L. **Bean.**

From Helsingfors, Finland. Presented by Mr. V. F. Sagulin. Received September 10, 1908.

Finnish runner bean.

23544 to 23547.

From Ningyuenfu, Szechuan, via Chengtu, China. Presented by Rev. R. Wellwood, American Baptist Mission. Received September 10, 1908.

Seed of each of the following. Varietal descriptions by Mr. H. T. Nielsen.

23544 to 23546. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

23544. Large yellow with dark hilum; similar in appearance to Nos. 19986 and 22877.

23545. Yellow with brown hilum; similar in appearance to No. 17862.

23546. Very small, black, smaller than any black-seeded soy bean we have had.

23547. PISUM ARVENSE L. **Field pea.**

23548. PSIDIUM GUAJAVA L. **Guava.**

From Bradentown, Fla. Presented by Mr. W. A. Berg, through Mr. Walter Fischer. Received September 16, 1908.

"Seed of the largest and finest fruit that I have yet seen. Weight, from 7 to 10 ounces; color of outside skin, green; when ripe the flesh is cream colored; fruit has a slight banana flavor and is late in ripening, coming in when others have gone. Flesh one-half inch thick. Seeds from 75 to 175 in number, bunched." (*Berg.*)

23549. ARACHIS HYPOGEA L. **Peanut.**

From Cochin China. Presented by Mr. J. E. Conner, American consul, Saigon, Cochin China. Received August 28, 1908.

"These are very small, very abundant as to the number of seeds, but about equal in weight to the yield of the Javanese peanut (about 1,700 pounds to the acre). Because of the smallness of the seed the officials at the Jardin Botanique hadn't any good words for it. I tried to discover whether they were bunched together more closely at the root of the plant, but without success. They are planted in rows, distanced 40 cm., the rows 50 cm. apart, in soil sandy, moist, and rich in nitrogen though poor in phosphoric acid, potassium, and lime." (*Conner.*)

23551 to 23623. SOLANUM TUBEROSUM L. **Potato.**

From Chile. Procured from Mr. José D. Husbands, Limavida, Chile, through Mr. Alfred A. Winslow, American consul, Valparaiso, Chile. Received at the Mississippi Valley Plant Introduction Garden, Ames, Iowa, August, 1908.

The following tubers. Descriptive notes by Prof. S. A. Beach, Mississippi Valley Plant Introduction Garden.

23551 to 23577.

"Each of these is a wild variety or class of its own, sent as found growing in the virgin bush on the hills, mountain sides, and lowlands on the island of the archipelagos de Chiloé and Guaitecas. They form the sole food of the Chilote Indians and other native inhabitants. These tubers grow abundantly in spots, often very deep in the ground or gravel. Many grow from self-sown, grown, and planted seedlings. These preserve their character and improve, increase in size, and also perfect their forms for five consecutive years, when they become established sorts. Thousands have to be dug to make small collections of new kinds. Often when a little tuber is found it must wait many days for its companion to be found far away. Generally all these improve with continued cultivation. They are all good eating, especially baked; some when boiled are inclined to dissolve, but with continued planting they outgrow this fault. A collection of seedlings is more effective to work on than sowing seeds, which grow in every direction but the desired, and frequently strike back to the worthless wild sorts." (*Husbands.*)

23551. Dark purple, elongated, irregular. Flesh dark in center, with purple line about darker portion.

23552. Red, elongated, irregular.

23553. Purple, round, flattened, regular.

23554. Purple, elongated, irregular.

23555. Dark purple, round or elongated, irregular. Flesh yellow.

23556. White, purple eyes and eyebrows, elongated.

23557. White, round or elongated, irregular.

23558. White, roundish but very irregular in shape, slightly flattened.

23559. Pink, elongated, irregular. Flesh contains a distinct line about half way from center to circumference.

23551 to 23623—Continued.

23551 to 23577—Continued.

23560. White, round. Flesh deep yellow.

23561. Red, elongated, irregular.

23562. Red, oblong, irregular.

23563. Pink, elongated, regular.

23564. Purple, round, one specimen knobby, regular.

23565. White around eyes, balance purple, round, flattened, regular.

23566. Purple, round, regular.

23567. White, round, regular.

23568. White, round, regular.

23569. White, elongated, regular.

23570. White, round, regular in size, irregular in shape.

23571. Purple, elongated or round, irregular.

23572. White, blotched with pink, round, irregular.

23573. Dark, mottled with purple, round, irregular.

23574. White, oblong, very irregular and knobby.

23575. White, round, regular.

23576. White, round, regular. Flesh deep yellow.

23577. White, elongated, flattened.

23578 to 23623.

"The following represent varieties of good potatoes of wild origin from the archipelago before named. There are no duplicates; if they are alike, they came from distant parts and were grown under such distinct conditions as to location, soil, moisture, plant food, etc., as to entitle them to new classification. The smallest that were suitable for seed were collected for economy of space, which is very limited when collecting tours are made on horseback. There are all sorts—white, yellow, pink, etc., fleshed. The yellow, and some white ones, are inclined to sweetness and are of extra fine flavor. If they retain their native merits when planted in such a distant home, you will get almost any result you seek. I have, however, proved to my satisfaction that extreme changes in localities and conditions influence and alter flavor, size, and shape. Many improve, others deteriorate. The red-skinned classes sent are bad forms, but are very fine sorts to eat. Their names are of no value, as they are local Chilote Indian names; often the same potato has a different name in every locality where grown. Some of these are seedlings of the second and third years' growth. These will improve in shape, size, and flavor by planting; at least they would do so if planted in Chile. Long cultivation has made the others standard sorts, which hold their own (in Chile) with indefinite continued sowing. It will be strange if some of these will not have an affinity with your conditions. Among these you will find some extra early, others late, mostly medium early; some with a very small plant growth, others rank. While all the flowers are true Solanum, they are of many different sorts and colors. Some roots spread largely and yield on new growth also; others stay in their proper places. Generally speaking, all are very productive and yield from 40 to 120 for one; 60 per plant would be a safe average. Another feature is their uniformity in size and shape. All these have grown dry in short summers; that is, with natural earth moisture and the extra heavy marine dews. I do not believe such tubers have ever been tested so far inland as Iowa. That they will reproduce themselves I have little hope. In my opinion they will be much better or worse; as likely to be one as the other. From experiments I have made in Chile, this is foretold. No one knows results, as no one has ever attempted such experiments as you will make, i. e., from seaward to such a far distance inland. I have gained better results from inland to seaward. If you were to send me potatoes from Iowa and ask me to plant

23551 to 23623—Continued.

23578 to 23623—Continued.

them in Chile and afterwards return the product, I do not believe you would recognize them in any particular. I write these things for information, and not as instruction. Very many of these potatoes do not rot if left in the ground through a winter of five months' continued rain. They must be on an inclined surface for drainage of the rain." (*Husbands.*)

23578. Light purple, round, regular.

23579. White, russeted, elongated, flattened.

23580. Red, round, irregular. Flesh with indistinct red line about outside ¼ inch from circumference. Flesh is streaked with red.

23581. White, russeted, slightly elongated and flattened.

23582. Faint purple, coarsely russeted, round, regular.

23583. White, dumb-bell shaped, irregular.

23584. White, elongated, flattened, regular.

23585. White, round, regular.

23586. White, elongated, flattened.

23587. Pink, elongated, flattened, irregular. Flesh deep yellow.

23588. White or red, mottled with purple, round, irregular.

23589. White, elongated, irregular.

23590. Dull red, elongated, flattened, regular.

23591. Red, slightly flattened, and oblong.

23592. Light red, round or elongated, irregular in shape and size. Mottled flesh. Much like water core in apples.

23593. White, round, irregular. Flesh contains yellow streaks.

23594. Purple, round, irregular, knobby.

23595. White, round or elongated, flattened, irregular.

23596. White, blotched with purple, round, irregular.

23597. Purple, slightly elongated, and flattened.

23598. White, some specimens russeted, irregular, slightly elongated. Flesh deep yellow.

23599. White, elongated, regular.

23600. Round, white, regular.

23601. Round, slightly flattened, irregular, white. Flesh yellow.

23602. White, elongated, regular.

23603. White, round, flattened, irregular.

23604. Red; several specimens round, the others oblong.

23605. White, pink around eyes, slightly elongated.

23606. White, elongated, irregular.

23607. Dull purple, round or elongated, flattened, irregular.

23608. White, elongated, regular. Flesh white. (Type A of Husbands.) White, round, irregular. Flesh deep yellow. (Type B of Husbands.)

23609. White, round, flattened, regular.

23610. White, round.

23611. White, russeted in patches, elongated, flattened, regular.

23612. Round.

23613. Red, elongated, flattened, regular. Flesh yellow.

23551 to 23623—Continued.

23578 to 23623—Continued.

23614. Purple with white around eyes, round, irregular. Flesh yellow, marked with red.

23615. White, elongated, irregular, uniform.

23616. Red, round, flattened, regular. Flesh streaked with red.

23617. White with pink eyes, elongated, irregular.

23618. Dull red, coarsely mottled in small patches, elongated, and flattened.

23619. Red, elongated, flattened, irregular. Flesh, deep yellow.

23620. White, elongated, irregular.

23621. Dull red, elongated, irregular.

23622. White, round or elongated, flattened, irregular.

23623. Red, elongated, knobby, irregular.

23625 to 23627.

From Orenburg, Russia. Presented by Mr. W. S. Bogdan, agronomist. Received September 8, 1908.

The following seeds:

23625. MEDICAGO FALCATA L.

23626. LATHYRUS TUBEROSUS L.

23627. GLYCYRRHIZA GLABRA L.

23631. COLCHICUM AUTUMNALE L. **Colchicum.**

From Baumschulenweg, near Berlin, Germany. Purchased from Mr. L. Späth, for Doctor True's experiments. Received September 17, 1908.

See No. 23436 for description.

23632 to 23643. MUSA spp. **Banana.**

From Ceylon. Procured by Dr. C. Drieberg, secretary, Ceylon Agricultural Society, Colombo, Ceylon, at the request of Mr. O. W. Barrett. Received September 4, 1908.

The following suckers:

23632. *Hambanpuwalu.*

23633. *Suramondan.*

23634. *Sudu Puwalu.*

23635. *Marthawalu.*

23636. *Kalu Rata Hondarawala.*

23637. *Suwadel.*

23638. *Kolikuttu.*

23639. *Rata Hondarawala.*

23640. *Maha Alumondan.*

23641. *Puspakedeli.*

23642. *Dalcna.*

23643. *Alumondan.*

"S. P. I. Nos. 23632 to 23641 and 23643 are varieties indigenous to Ceylon, while S. P. I. No. 23642 is a variety imported from Queensland some time since, but is by no means an improvement on the Ceylon varieties. Varieties S. P. I. Nos. 23637 and 23638 are generally considered the best." (*Drieberg.*)

23644. COELOCOCCUS AMICARUM (Wendl.) W. F. Wight. **Caroline ivory-nut palm.**

From Philippine Islands. Presented by Mr. William S. Lyon, Gardens of Nagtajan, Manila, P. I. Received September 21, 1908.

See No. 21044 for description.

23645. VIOLA CALCARATA L.

From Kew, England. Presented by Mr. David Prain, director, Royal Botanic Gardens. Received September 21, 1908.

"Introduced for the purpose of hybridizing with the common pansy to produce an improved pansy that will withstand hot summer weather." (*Oliver.*)

23646 and 23647. CERATONIA SILIQUA L. **Carob.**

From Lisbon, Portugal. Secured by Mr. Louis H. Aymé, American consul-general. Received September 21, 1908.

Cuttings of each of the following. The name of the plantation, proprietor, and the average annual production of the tree from which the grafts were cut are given.

23646. From Chão das Donas, plantation of Antonio José da Motta; yield 35 to 40 pounds per annum.

23647. From Valle de Arrencada, plantation of Joaquin Traquino; yield 15 to 20 pounds per annum.

These cuttings were procured to take the place of similar ones received in 1907 and listed under Nos. 20962 and 20963, but which died.

23650. SOLANUM MURICATUM Ait. **Pepino.**

From Teneriffe, Canary Islands. Presented by Mr. Solomon Berliner, American consul, through the Department of State. Received September 21, 1908.

"Cuttings of a fruit known here as 'pera melon,' or melon pear. This fruit grows on bushes about 2 or 3 feet high and when ripe is yellow and the shape of a melon; in taste it is a blend between a cantaloupe and a pear." (*Berliner.*) (See No. 21546 for other importations of above.)

23656. ROSA MOYESI Hort. **Rose.**

From London, England. Purchased from James Veitch & Sons. Received September 23, 1908.

"A very distinct Chinese species of dense habit and with very spiny growths and leaves. The latter have in most cases nine or eleven pinnæ and they are very deep green. The flowers are nearly 3 inches across, rounded, single, and made up of very thick, substantial petals. The color is deep, rich, rosy red, but the buds are of brighter hue. This new rose should prove of great value in the creation of a new race of garden roses." (*James Veitch & Sons.*)

23658. CITRUS TRIFOLIATA L.

From Santa Ines, Chile. Purchased from Mr. S. Izquierdo, through Mr. W. T. Swingle. Received September 25, 1908.

"I cultivated this species here and it is the stock which I use for grafting the citrus varieties producing fruits for the trade." (*Izquierdo.*)

23659. MEDICAGO SATIVA L. **Alfalfa.**

From Lindsborg, Kans. Presented by Mr. Carl Wheeler, through Mr. J. M. Westgate. Received September 25, 1908.

Hungarian. "Said to be a part of a heavy shipment from Hungary to South America, but which could not be marketed in South America owing to financial stringency; several carload lots were sold to Kansas seed houses under the name of *Hungarian* alfalfa. Said to be a very hardy variety. To be grown for comparison and identification." (*Westgate.*)

23660. PHALARIS COERULESCENS Desf.

From Paris, France. Purchased from Vilmorin-Andrieux & Co. Received September 25, 1908.

See No. 22961 for description.

23662 to 23710. ERIOBOTRYA JAPONICA (Thunb.) Lindl. **Loquat.**

Reciprocal loquat crosses, raised at the Department greenhouses by Mr. G. W. Oliver, plant propagator. Numbered for convenience in recording distribution September, 1908.

23662 to 23710—Continued.

Plants of each of the following:

23662 to 23683.

Olivier × *Tanaka.*

23684 to 23710.

Tanaka × *Olivier.*

The above crosses were made between *Olivier*, S. P. I. No. 6457, and *Tanaka*, S. P. I. No. 8890.

23711. CITRULLUS VULGARIS Schrad.

From Egypt. Presented by Mr. Hubert S. Smiley, Gallowhill, Paisley, Scotland. Received September 23, 1908.

"Seeds of the 'Boutique el Zeit,' commonly known as the 'unedible watermelon.' This comes from south of the Bahr el Ghael and round the port of Rumhek. The natives grow it after the rains and extract the seeds and boil them. The result is an oily film on top of the water. This is removed and the process continued until an oil is procured which is said to be very good for lighting purposes. Perhaps this plant would be of service to people in out-of-the-way parts of your country. The melon is unedible." (*Smiley.*)

23712. FESTUCA RUBRA DUMENTORUM (L.) Hackel.

Chewing's fescue.

From Wellington, New Zealand. Presented by Mr. T. W. Kirk, biologist, Department of Agriculture, through Mr. C. V. Piper. Received September 28, 1908.

23713. EUCALYPTUS MICROTHECA F. Muell.

From Australia. Presented by Mr. W. R. Guilfoyle, director, Botanic and Domain Gardens, Melbourne, who procured it from J. Staer & Co., seedsmen, etc., Wahroonga, New South Wales. Received September 29, 1908.

See No. 23495 for description.

23714 to 23733.

From East Africa. Received through Mr. O. W. Barrett, Director of Agriculture, Lourenco Marquez, Portuguese East Africa, September 21, 1908.

The following seeds:

23714. ANDROPOGON SORGHUM (L.) Brot.

"(No. 1.) 'A sweet sorghum' in cultivation by the M'chopes Kafirs of Zavala section of Inharrime district. Height, 2.5 to 3.5 meters. Crop (second) in July." (*Barrett.*)

"Hackel's variety *roxburghii.* A 14-inch panicle, loose and open, with very slender branches. Type of the Madagascar ampembies. Glumes rather broad, reddish, hairy, becoming involute and gaping at maturity. Seeds broadly oval, pearly white." (*Carleton R. Ball.*)

23715. ANDROPOGON SORGHUM (L.) Brot.

"(No. 2.) A goose-neck variety in common cultivation by Kafirs in Gazaland. The best of about 6 more or less distinct sorts. Height, 3 to 6 meters. Prefers heavy alluvial soil. Native name (usually) *mapira.*" (*Barrett.*)

"Fragments of the head of a white-seeded sorghum probably similar to the preceding (S. P. I. No. 23715). Glumes shorter and firmer, but involute and gaping. Seeds nearly circular." (*Carleton R. Ball.*)

23716. ANDROPOGON SORGHUM (L.) Brot.

"(No. 3.) A straight blackhull variety in cultivation by natives of lower Zambezi Valley. Height 3 to 4 meters." (*Barrett.*)

23714 to 23733—Continued.

"Variety *roxburghii* Hackel. A 14-inch head, typical, branches extremely slender, glumes narrowly ovate to lanceolate, acuminate, deep mahogany red, involute and gaping at maturity. Seeds white, oval, subacute, very similar to *shallu*." (*Carleton R. Ball.*)

23717. VERNONIA SP. (?)

"(No. 4.) Rambling shrub common in Gaza and Inharrime districts. Flowers fragrant, numerous, of unstable colors (white to bluish or rose). Ornamental. Height 5 to 10 meters." (*Barrett.*)

23718. CANAVALI OBTUSIFOLIUM (Lam.) DC.

"(No. 5.) A wild vine in open 'bush' between Chai-Chai and Inhambane. Length 4 to 8 meters." (*Barrett.*)

23719. CANAVALI OBTUSIFOLIUM (Lam.) DC.

"(No. 6.) A wild vine in 'bush' and along river banks in lower Zambezi Valley. Length 4 to 10 meters." (*Barrett.*)

23720. VIGNA UNGUICULATA (L.) Walp. Cowpea.

"(No. 7.) A 'Kafir bean' in cultivation in the province of Inhambane. Rare." (*Barrett.*)

23721. VIGNA UNGUICULATA (L.) Walp. Cowpea.

"(No. 8.) A very common 'Kafir bean' in Portuguese East Africa. A smaller form is not so common. Sandy soil preferred. Yield in fair soil, 5 bags (80 kilos each?) per hectare." (*Barrett.*)

23722. ELEUSINE CORACANA (L.) Gaertn. **Ragi millet.**

"(No. 9.) A common crop in the lower Zambezi Valley. Prefers heavy alluvial soil. Height 1½ to 2 feet. Local name *naxenim;* Ichuabo name *merúbi*." (*Barrett.*)

23723. ASTRAGALUS PROLIXUS Sieber.

"(No. 10.) An erect, much-branched leguminous herb in open veld in lower Zambezi Valley. Height about 1 meter." (*Barrett.*)

23724. INDIGOFERA SP. (?)

"(No. 11.) A wild woody herb of the open veld in the lower Zambezi Valley. Height 1 to 1½ meters." (*Barrett.*)

23725. CROTALARIA PODOCARPA DC.

"(No. 12.) A wild woody herb of the open veld in the lower Zambezi Valley. Height ½ to 1 meter." (*Barrett.*)

23726. INDIGOFERA HIRSUTA L.

"(No. 13.) A woody herb of the open 'bush' and alluvial plains of Gaza and Inhambane. Height 1 meter." (*Barrett.*)

23727. INDIGOFERA sp. (?)

"(No. 14.) A creeping leguminous herb in sandy soils in Limpopo Valley (Gaza). A possible cover crop in sandy regions." (*Barrett.*)

23728. GOSSYPIUM sp. (?) Cotton.

"(No. 16.) A dwarf wild cotton of the open veld in scattered districts of Portuguese East Africa. Height about ½ to 1 meter. Prolific." (*Barrett.*)

23729. SPATHODEA sp. (?)

"(No. 17.) *'Ngain.* A close-branched evergreen tree of the 'bush' in Gaza. Suitable for a wind belt. Flowers rather large, whitish." (*Barrett.*)

23730. VIGNA sp. (?)

"(No. 18.) A leguminous vine of the 'bush' and veld. Length, 4 to 8 meters." (*Barrett.*)

23731. TELFAIREA PEDATA (Smith) Hook.

"(No. 19.) A gigantic cucurbit apparently wild in the 'bush' of Inhambane. Diœcious. Plants live two or three years and attain

23714 to 23733—Continued.

diameter at the base of some 6 inches (47 centimeters in circumference). Seeds numerous in large (12 to 18 inches in diameter) fruit. Oil of good quality; kernels said to contain 60 per cent. Planted as a new oil crop." (*Barrett.*)

23732. SOPHORA TOMENTOSA L.

"(No. 20.) A gray-leaved shrub or small tree growing in sand in the coast region of the Mozambique Company's territory. Suitable for a wind hedge in Florida." (*Barrett.*)

23733. MUCUNA sp.

"(No. 21.) Seeds found on bank of Chinde River (the north mouth of the Zambezi)." (*Barrett.*)

23734 to 23739.

From Sibpur, Calcutta, India. Presented by Mr. W. W. Smith, acting superintendent, Royal Botanic Garden. Received August 21, 1908.

The following seeds:

23734. TAMARINDUS INDICA L. **Tamarind.**

Sweet.

23735. CAJAN INDICUM Spreng.

"May help us where grown in cotton fields to enrich the soil; better than cowpeas." (*H. E. Van Deman.*)

23736 to 23739. MANGIFERA INDICA L. **Mango.**

23736. *Copalbhog.* (See No. 10640 for previous introduction.)

23737. *Khirsapati.*

23738. *Malda.* (See No. 9808 for previous introduction.)

23739. *Kissenbhog.*

23740 to 23744.

From Wellington, New Zealand. Presented by Mr. T. W. Kirk, biologist, Department of Agriculture. Received September 30, 1908.

The following seeds. Native names in quotations.

23740. DYSOXYLUM SPECTABILE (Forst.) Hook.

Kohekohe. "A handsome round-headed tree 25 to 50 feet high, 1 to 3 feet in diameter; flowers waxy white.

"Timber suitable for inlaying and furniture; leaves bitter and tonic." (*Extract from Cheeseman's Man. N. Zeal. Fl.*)

23741. SOPHORA TETRAPTERA J. Mill.

Kowhai. "A small tree with exceedingly hard and durable wood, which can be used for cog wheels and other select structures. Trunk exceptionally attaining a diameter of 3 feet. The wood differs much from that of *S. tomairo* of the Easter Islands [Dr. Phillippi]." (*Von Mueller.*)

23742. NAGEIA EXCELSA (D. Don) Kuntze. (PODOCARPUS DACRYDIOIDES A. Rich.).

White pine, or *Kahikatea.* "One of the tallest trees of the colony; said to occasionally attain the height of 150 feet. The wood is white or pale yellow, tough and compact, straight grained and easily worked, but unfortunately not durable when in contact with the ground or where regularly exposed to dampness. It is very suitable for inside work of all kinds." (*T. F. Cheeseman, Fl. N. Zealand.*)

23743. MYRSINE URVILLEI A. DC.

"*Te Pau.*" "This is a small closely branched tree, 10 to 20 feet high; bark red on the young branches. The leaves are alternate, oblong, nearly smooth, margins undulate. The flowers are crowded in fascicles on the

23740 to 23744—Continued.

branches below the leaves; small, whitish. The ovary has a large sessile-fringed stigma. The fruits are small, round, and black.

"These characters seem to me to be of importance in an ornamental way, if the tree will stand our climate." (*H. C. Skeels.*)

23744. Clianthus puniceus (Don) Soland.

"This is an old-fashioned greenhouse plant, grown sometimes to cover rafters or trellis work, but more frequently trained around sticks placed around the edge of the pot. Cultivated in eastern greenhouses, and a favorite Californian outdoor shrub. Blooms all winter in Golden Gate Park, San Francisco. The flowers, not very unlike those of the common Erythrina, are freely produced in hanging clusters. Cuttings rooted in early spring may be grown into good-sized plants during the summer. Water should be given sparingly during the dull months. Pruning, repotting, and tying the shoots should be done just before the growth begins. A sharp lookout should be kept for the red spider, frequent syringings being the only remedy for this pest." (*G. W. Oliver and W. M., in Encyc. of Amer. Hort.*)

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